LINEAR
INTEGRATED CIRCUITS

National

LINEAR JUN 1973 National

Introduction

Here is the new Linear Data Handbook from National. It gives complete specifications for devices useful in building nearly all types of electronic systems, from communications and consumer-oriented circuits to precision instrumentation and computer designs.

For information regarding newer devices introduced since the printing of this handbook, or for further information on listed parts, please contact our local representative, distributor, or regional office.

LINEAR

- Operational Amplifiers
- Interface Circuits
  - Sense Amplifiers
  - Peripheral Drivers
  - Line Drivers/Receivers
- Voltage Regulators
- Consumer Circuits
  - T.V.
  - Communication Circuits
  - Audio
- Comparators/Buffers
- Hybrids
  - Analog Switches
  - Drivers
  - Operational Amplifiers

DIGITAL

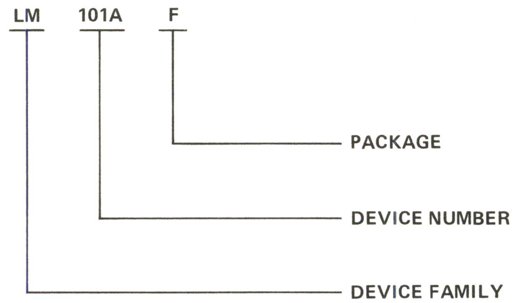
- MOS
  - Shift Registers
  - Read Only Memories
  - Logic Elements
  - Analog Switches
  - Hybrid Clock Drivers
- TTL
  - Series 54/74
  - Series 54L/74L
  - Series 74H
  - Hybrid Drivers
  - Tri-State® Logic
- DTL
  - Series 930
- HYBRIDS
  - Interface Circuits
  - Analog Switches
  - Drivers
  - Operational Amplifiers

TRANSISTORS

- Power
- NPN & PNP Small Signal Silicon Transistors
- Field Effect Transistors
  - Amplifiers & Switches
  - Monolithic Duals

Ordering Information

The ordering information for National devices covered in this catalog is as follows:



DEVICE FAMILY

AH — Analog Hybrid
AM — Analog Monolithic
DM — Digital Monolithic
LH — Linear Hybrid
LM — Linear Monolithic
LX — Transducer
MM — MOS Monolithic

DEVICE NUMBER

3, 4 or 5 digit number.

Suffix Indicators:

A — Improved Electrical Specification
C — Reduced Temperature Range

PACKAGE

D — Glass/Metal Dual-In-Line Package
F — Flat Package (0.25" wide)
G — TO-8 (12 lead) Metal Can
H — TO-5 (multi-lead) Metal Can
J — Glass/Glass Dual-In-Line Package
K — TO-3 Power Package
N — Molded Dual-In-Line Package
T — TO-220 Plastic Power Package
W — Flat Package (0.275" wide)

Devices are listed in the table of contents alpha-numerically by device family (LH, LM, LX, etc.) and then by device number. **With most of National's proprietary linear circuits, a 1-2-3 numbering system is employed. The 1 denotes a Military temperature range device (-55°C to +125°C), the 2 denotes an Industrial temperature range device (-25°C to +85°C), and the 3 denotes a Commercial temperature range device (0°C to +70°C), i.e. LM101/LM201/LM301.**

Exceptions to this are the LM1800 series of consumer circuits which are specified for the commercial temperature range; some hybrid circuits which employ a "C" suffix to denote the commercial temperature range; and second-source products which follow the original manufacturers numbering system, i.e. LM741/LM741C or LM1414/LM1514.

Digital products, interface circuits, and sense amplifiers employ a 55 as the first two digits for the military temperature range part, and a 75 for the commercial part, i.e. LM5520/LM7520. Display drivers and line drivers and receivers employ a 78/88 prefix. The 78 applies to the military part, and the 88 to the commercial part, i.e. DM7830/DM8830.

Parts are generally listed in the table of contents by the military part number first such as the LM139/LM239/LM339, except where a separate data sheet is employed for different temperature range, i.e. LM119/LM219, and a separate LM319, or where only one temperature range exists, i.e. LM340.

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MILITARY TEMPERATURE RANGE: −55°C to +125°C

Device	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Typ (μV/°C)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain Min (Volts/V)	Bandwidth A_V = 1 Typ (MHz)	Slew Rate A_V = 1 TYP (V/μs)	Output Current (mA)	Supply Voltage Min (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mW)	Compensation Components	Package Types
LH0001	1	4	20	100	25,000	1	.25	±5	±5	±20	$\pm V_s$	±7	.5	2	TO-5
LH0001A	2.5	3	20	100	25,000	1	.25	±5	±5	±20	$\pm V_s$	±7	.5	2	TO-5 DIP F.P.
LH0002	30	(Note 2)	10×10^3	10^4	.95	50	100	±100	±5	±22	$\pm V_s$	(Note 2)	100	0	TO-5 DIP
LH0003	3	4	200	2000	15	30 (Note 1)	30 (Note 1)	±50	±5	±20	$\pm V_s$	±7	30	2	TO-5
LH0004	1	4	20	100	30	1	.25	±15	±5	±45	$\pm V_s$	±7	1.5	2	TO-5
LH0005	10	20	20	50	2	30 (Note 1)	20 (Note 1)	±50	±9	±20	$\pm V_s$	±15	90	3	TO-5
LH0020	2.5	10	50	250	100,000	1	.25	±40	±5	±22	$\pm V_s$	±30	50	2	TO-5
LH0021	3	3	100	300	100,000	1	3	±1000	±5	±18	$\pm V_s$	±30	35	0	TO-3
LH0022	4	5	.002	.01	100,000	1	3	±10	±5	±22	$\pm V_s$	±30	35	0	TO-5 DIP F.P.
LH0024	4	20	3×10^3	20×10^3	4000	50	400	±100	±9	±18	$\pm V_s$	±5	252	1	TO-5
LH0032	5	25	.01	.02	1000	50	500	±100	±5	±18	$\pm V_s$	±30	200	2	TO-8
LH0033	10	(Note 3)	(Note 3)	.1	.97 (Note 3)	100	1500	±100	±5	±20	$\pm V_s$	(Note 3)	220	0	TO-8 8 PIN J
LH0041	3	3	100	300	100,000	1	3	±200	±5	±18	$\pm V_s$	±30	35	0	TO-8 8 PIN J
LH0042	20	5	.005	.025	50,000	1	3	±10	±5	±22	$\pm V_s$	±30	35	0	TO-5 DIP F.P.
LH0052	.5	2	.0001	.001	100,000	1	3	±10	±5	±22	$\pm V_s$	±30	25	0	TO-5 DIP
LH0061	4	5	100	300	50,000	15	70	±500	±5	±18	$\pm V_s$	(Note 4)	100	1	TO-3
LH0062	5	5	.001	.025	50,000	15	70	±6	±5	±20	$\pm V_s$	±30	80	0	TO-5 DIP
LH0063	25	(Note 1)	(Note 3)	.2	.96 (Note 3)	150	6000	±400	±5	±18	$\pm V_s$	(Note 3)	500	0	TO-3

Note 1: Specified for A_V = −10.
Note 2: Current booster.
Note 3: Voltage follower.
Note 4: Inputs have shunt-diode protection; current must be limited to ±10 mA.

Military Op Amp Selection Guide

MILITARY TEMPERATURE RANGE: $-55^\circ C \leq T_A \leq +125^\circ C$

Device	Input Offset Voltage† Max (mV)	Input Offset Voltage Drift Max (μV/°C)	Input Offset Current† Max (nA)	Input Bias Current† Max (nA)	Voltage Gain† (Volts/V)	Bandwidth $A_V = 1$ Typ (MHz)	Slew Rate $A_V = 1$ Typ (V/μs)	Output Current Max (mA)	Supply Voltage Min Typ (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current† Max (mA)	Compensation Components	Package Types
LH101	6	6	500	1500	50k	1	.5	5	±3	±22	±12	±30	3	0	TO-5 F.P.
LM101	6	6	500	1500	50k	1	.5	5	±3	±22	±12	±30	3	1	TO-5 F.P.
LM101A LH2101A (Note 1)	3	15	20	100	50k	1	.5	7.5	±3	±22	±12	±30	3	1	TO-5 DIP F.P.
LM102	7.5	6 typ	*	100	.999	10	10	1	±12	±18	±10	*	5.5	1	TO-5
LM107	3	15	20	100	50k	1	.5	7.5	±3	±22	±12	±30	3	0	TO-5 DIP F.P.
LM108 LH2108 (Note 1)	3	15	.4	3	50k	1	.3	1	±2	±20	±14	(Note 2)	.6	1	TO-5 DIP F.P.
LM108A LM2108A (Note 1)	1	5	.4	3	80k	1	.3	1	±2	±20	±14	(Note 2)	.6	1	TO-5 DIP F.P.
LM110 LH2110 (Note 1)	6	12	*	10	.999	20	30	1	±5	±18	±10	*	5.5	0	TO-5 DIP
LM112	3	15	.4	3	50k	1	.2	1	±2	±20	±14	(Note 2)	.6	0	TO-5 DIP F.P.
LM118	4	*	50	250	50k	15	50 min†	5	±5	±18	±11.5	(Note 2)	7	0	TO-5 DIP F.P.
LM124 (Quad)	5	*	30	300	100k	1	*	40	5 (±1.5)	32 (±15)	$V^+ - 1.5$	32	2	0	DIP F.P.
LM709	6	6	500	1500	25k	1	.3	5	±9	±18	±8	±5	5.5	3	TO-5
LM725	1.5	5	40	200	1000	.5	.005	5	±3	±22	±13.5†	±5	3.5	4	TO-5 F.P.
LM741	6	*	500	1500	50k	1	.5	5	±3	±22	±12	±30	2.9	0	TO-5 DIP F.P.
LM747	6	*	500	1500	50k	1	.5	5	±3	±22	±12	±30	5.6	0	TO-5 DIP F.P.
LM748	6	6	500	1500	50k	1	.5	5	±3	±22	±12	±30	2.9	1	TO-5
LM1558 (Dual)	6	*	500	1500	50k	1	.5	5	±3	±22	±12	±30	2.9	0	TO-5
LM4250 LH24250 (Note 1)	4	*	5	15	100k	.25	.16	.75	±1	±18	±12	±15	.03 set	0	TO-5

*Not specified.
†Guaranteed at +25°C.

Note 1: Dual version of device.
Note 2: Inputs have shunt-diode protection; current must be limited.

INDUSTRIAL TEMPERATURE RANGE: −25°C to +85°C

Device	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Typ (μV/°C)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain Min (Volts/V)	Bandwidth $A_V = 1$ Typ (MHz)	Slew Rate $A_V = 1$ Typ (V/μs)	Output Current (mA)	Supply Voltage Min (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mW)	Compensation Components	Package Types
LH0001AC	5	3	60	200	.25	1	.25	±5	±5	±20	$\pm V_s$	±7	1.3	2	TO-5 DIP F.P.
LH0002C	30	(Note 2)	10×10^3	10^4	.95 (Note 2)	50	100	±100	±5	±22	$\pm V_s$	(Note 2)	100	0	TO-5 DIP
LH0003C	3	4	200	2000	15,000	30 (Note 1)	30 (Note 1)	±50	±5	±20	$\pm V_s$	±7	30	2	TO-5
LH0004C	1.5	4	45	120	30,000	1	.25	±15	±5	±45	$\pm V_s$	±7	1.5	2	TO-5
LH0005C	10	25	25	100	2000	30 (Note 1)	20 (Note 1)	±50	±9	±20	$\pm V_s$	±15	90	3	TO-5
LH0020C	6	10	200	500	50,000	1	.25	±100	±5	±18	$\pm V_s$	±30	50	2	TO-5
LH0021C	6	5	200	500	100,000	1	3	±1000	±5	±18	$\pm V_s$	±30	40	0	TO-3
LH0022C	6	5	.005	.025	75,000	1	3	±10	±5	±22	$\pm V_s$	±30	24	0	TO-5 DIP F.P.
LH0024C	8	25	5×10^3	22×10^3	3500	50	400	±100	±9	±18	$\pm V_s$	±5	252	1	TO-5
LH032C	15	25	.02	.5	700	50	500	±100	±5	±20	$\pm V_s$	±30	220	2	TO-8
LH0033C	20	(Note 3)	(Note 3)	.15	.96 (Note 3)	100	1500	±100	±5	±20	$\pm V_s$	(Note 3)	240	0	TO-8 8 PIN J
LH0041C	6	5	200	500	100,000	1	3	±200	±5	±18	$\pm V_s$	±30	40	0	TO-8 8 PIN J
LH0042C	20	10	.01	.05	25,000	1	3	±10	±5	±22	$\pm V_s$	±30	28	0	TO-5 DIP F.P.
LH0052C	1	5	.0002	.005	75,000	1	3	±10	±5	±22	$\pm V_s$	±30	30	0	TO-5 DIP
LH0061C	10	5	200	200	25,000	15	70	±500	±5	±18	$\pm V_s$	(Note 4)	150	1	TO-3
LH0062C	15	10	.002	.065	25,000	15	70	±6	±5	±20	$\pm V_s$	±30	120	0	TO-5 DIP
LH0063C	50	(Note 3)	(Note 3)	.2	.96 (Note 3)	150	6000	±400	±5	±18	$\pm V_s$	(Note 3)	500	0	TO-3

Note 1: Specified for $A_V = -10$.
Note 2: Current booster.
Note 3: Voltage follower.
Note 4: Inputs have shunt-diode protection; current must be limited to ±10 mA.

Industrial Op Amp Selection Guide

INDUSTRIAL TEMPERATURE RANGE: $-25°C \leq T_A \leq +85°C$

Device	Input Offset Voltage† Max (mV)	Input Offset Voltage Drift Max ($\mu V/°C$)	Input Offset Current† Max (nA)	Input Bias Current† Max (nA)	Voltage Gain† (Volts/V)	Bandwidth $A_V = 1$ Typ (MHz)	Slew Rate $A_V = 1$ Typ ($V/\mu s$)	Output Current Max (mA)	Supply Voltage Min Typ (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current† Max (mA)	Compensation Components	Package Types
LM201A LH2201A (Note 1)	2	15	20	75	25k	1	.5	5	±3	±22	±12	±30	3	1	TO-5 DIP F.P.
LM202	10	15 typ	*	15	.999	10	10	1	±12	±18	±10	*	5.5	0	TO-5
LM207	2	20	20	75	25k	1	.5	5	±3	±22	±12	±30	3	0	TO-5 DIP F.P.
LM208 LH2208 (Note 1)	2	15	.2	2	50k	1	.3	1	±2	±20	±14	(Note 2)	.4	1	TO-5 DIP F.P.
LM208A LH2208A (Note 1)	.5	5	.2	2	80k	1	.3	1	±2	±20	±14	(Note 2)	.4	1	TO-5 DIP F.P.
LM210 LH2210 (Note 1)	4	*	*	3	.999	20	30	1	±5	±18	±10	*	5.5	0	TO-5 DIP F.P.
LM212	2	15	.2	2	50k	1	.3	1	±2	±20	±14	(Note 2)	.6	0	TO-5 DIP F.P.
LM216	10	*	.05	.15	10k	1	.3	1	±5	±20	±13	(Note 2)	.8	0	TO-5 DIP F.P.
LM216A	3	*	.015	.05	20k	1	.3	1	±5	±20	±13	(Note 2)	.6	0	TO-5 DIP F.P.
LM218	4	*	50	500	50k	15	50 min†	5	±5	±18	±11.5	(Note 2)	7.5	0	TO-5 DIP F.P.
LM224 (Quad)	7	*	50	500	100k	1	*	40	3 (±1.5)	30 (±15)	$V^+ - 1.5$	32	2	0	DIP
LM725B	1.5	10	20	100	500k	.5	.005	5	±3	±22	±13.5	±5	4	4	TO-5 DIP
LM2900 (Quad)	*	*	*	200	2.8k	2.5	20	18	4	36	*	*	10	0	DIP

*Not specified.
†Guaranteed at +25°C.

Note 1: Dual version of device.
Note 2: Inputs have shunt-diode protection; current must be limited.

COMMERCIAL TEMPERATURE RANGE: $0^{\circ}C \leq T_A \leq +70^{\circ}C$

Device	Input Offset Voltage† Max (mV)	Input Offset Voltage Drift Max ($\mu V/^{\circ}C$)	Input Offset Current† Max (nA)	Input Bias Current† Max (nA)	Voltage Gain† (Volts/V)	Bandwidth $A_V = 1$ Typ (MHz)	Slew Rate $A_V = 1$ Typ ($V/\mu s$)	Output Current Max (mA)	Supply Voltage Min Typ (V)	Supply Voltage Max Typ (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current† Max (mA)	Compensation Components	Package Types
LH201	7.5	10	500	1500	20k	1	.5	5	±3	±22	±12	±30	3	0	TO-5 F.P.
LM201	7.5	10	500	1500	20k	1	.5	5	±3	±22	±12	±30	3	1	TO-5 F.P.
LM301A LH2301A (Note 1)	7.5	30	50	250	25k	1	.5	5	±3	±18	±12	±30	3	1	TO-5 DIP
LM302	15	20 typ	*	30	.9985	10	10	1	±12	±18	±10	*	5.5	0	TO-5
LM307	7.5	30	50	250	25k	1	.5	5	±3	±18	±12	±30	3	0	TO-5 DIP F.P.
LM308 LM2308 (Note 1)	7.5	30	1	7	25k	1	.3	1	±2	±18	±14	(Note 2)	.8	1	TO-5 DIP F.P.
LM308A LM2308A (Note 1)	.5	5	1	7	80k	1	.3	1	±2	±20	±14	(Note 2)	.8	1	TO-5 DIP F.P.
LM310 LH2310 (Note 1)	7.5	*	*	7	.999	20	30	1	±5	±18	±10	*	5.5	0	TO-5 DIP F.P.
LM312	7.5	30	1	7	25k	1	.3	1	±2	±18	±14	(Note 2)	.8	0	TO-5 DIP F.P.
LM316	10	*	.05	.15	20k	1	.3	1	±5	±20	±13	(Note 2)	.8	0	TO-5 DIP F.P.
LM316A	3	*	.015	.05	40k	1	.3	1	±5	±20	±13	(Note 2)	.6	0	TO-5 DIP F.P.
LM318	12	*	200	600	25k	15	50 min	5	±5	±18	±11.5	(Note 2)	10	0	TO-5 DIP
LM324 (Quad)	7	*	50	500	100k	1	*	40	3 (±1.5)	30 (±15)	$V^+ - 1.5$	32	2	0	DIP
LM709C	7.5	12	500	1500	25k	1	.3	5	±9	±18	±8	±5	6.6	3	TO-5 DIP
LM725C	2.5	2	35	125	250k	.5	.005	5	±3	±22	±13.5	±5	5	4	TO-5 DIP
LM741C	6	*	200	500	20k	1	.5	5	±3	±18	±12	±30	2.9	0	TO-5 DIP
LM747C	6	*	200	500	20k	1	.5	5	±3	±18	±12	±30	5.6	0	TO-5 DIP F.P.
LM748C	6	6	200	500	50k	1	.5	5	±3	±18	±12	±30	2.9	1	TO-5 DIP
LM1458 (Dual)	6	*	200	500	20k	1	.5	5	±3	±18	±12	±30	2.9	0	TO-5 DIP
LM3900 (Quad)	*	*	*	200	2.8k	2.5	20	10	4 (±2)	36 (±18)	*	*	10	0	DIP
LM4250C LH24250C (Note 1)	6	*	10	30	75k	.25	.16	.75	±1	±18	±12	±15	.03 set	0	TO-5 DIP

*Not specified.
†Guaranteed at +25°C.

Note 1: Dual version of device.
Note 2: Inputs have shunt-diode protection; current must be limited.

Commercial Op Amp Selection Guide

Fixed Voltage Regulator Guide

	Product Type No.	Input Voltage (V) Min	Input Voltage (V) Max	Output Voltage (V) Typ	Load Regulation (mV) Typ	Line Regulation (mV) Typ	Ripple Rejection (dB) Typ	Long Term Stability (mV) Max	Output Noise Voltage (μV) Typ	Quiescent Current (mA)	Operating Temperature Range (°C) Min	Operating Temperature Range (°C) Max	Output Current† (Amps)	Package Type
Positive Regulators	LM109K*	7	35	5	50	4	75	10	40	6	−55	125	>1	TO-3, TO-5
	LM209K*	7	35	5	50	4	75	10	40	6	−25	85	>1	TO-3, TO-5
	LM309K*	7	35	5	50	4	75	20	40	6	0	70	>1	TO-3, TO-5
	LM123K	7.5	20	5	50	4	75	10	40	6	−55	125	3	TO-3
	LM223K	7.5	20	5	50	4	75	10	40	6	−25	85	3	TO-3
	LM323K	7.5	20	5	50	4	75	20	40	6	0	70	3	TO-3
	LM340-05	7	35	5	100 max	100 max	70	20	40	6	0	70	>1	TO-3, TO-220
	LM340-06	8	35	6	120 max	120 max	65	24	45	6	0	70	>1	TO-3, TO-220
	LM340-08	10	35	8	160 max	160 max	62	32	52	6	0	70	>1	TO-3, TO-220
	LM340-12	14	35	12	240 max	240 max	61	48	75	6	0	70	>1	TO-3, TO-220
	LM340-15	17	35	15	300 max	300 max	60	60	90	6	0	70	>1	TO-3, TO-220
	LM340-18	20	35	18	360 max	360 max	59	72	110	6	0	70	>1	TO-3, TO-220
	LM340-24	26	40	24	480 max	480 max	56	96	170	6	0	70	.8	TO-3, TO-220
Negative Regulators	LM120K-5*	−6	−25	−5	50	10	67	50	150	2	−55	125	>1	TO-3, TO-5
	LM220K-5*	−6	−25	−5	50	10	67	50	150	2	−25	85	>1	TO-3, TO-5
	LM320K-5*	−6	−25	−5	50	10	67	50	150	2	0	70	>1	TO-3, TO-5
	LM120K-5.2*	−6.2	−25	−5.2	50	10	67	50	150	2	−55	125	>1	TO-3, TO-5
	LM220K-5.2*	−6.2	−25	−5.2	50	10	67	50	150	2	−25	85	>1	TO-3, TO-5
	LM320K-5.2*	−6.2	−25	−5.2	50	10	67	50	150	2	0	70	>1	TO-3, TO-5
	LM120K-12*	−13	−30	−12	30	4	80	120	400	4	−55	125	>1	TO-3, TO-5
	LM220K-12*	−13	−30	−12	30	4	80	120	400	4	−25	85	>1	TO-3, TO-5
	LM320K-12*	−13	−30	−12	30	4	80	120	400	4	0	70	>1	TO-3, TO-5
	LM120K-15*	−16	−30	−15	30	5	80	150	400	4	−55	125	>1	TO-3, TO-5
	LM220K-15*	−16	−30	−15	30	5	80	150	400	4	−25	85	>1	TO-3, TO-5
	LM320K-15*	−16	−30	−15	30	5	80	150	400	4	0	70	>1	TO-3, TO-5

*Ratings are for TO-3(K) package; device also available in TO-5(H) package.
†Max output current depends on package type, heat sinking, and input voltage differential.

Specifications Are Worst Case Over Operating Temperature Unless Noted.

	Product Type No.	Input Voltage Range (V) Min	Input Voltage Range (V) Max	Output Voltage Range (V) Min	Output Voltage Range (V) Max	Load Regulation (%) Typ.	I_L (mA)	Line Regulation ($\%V_{OUT}/\Delta V_{IN}$) Typ.	Ripple Rejection (%) Typ.	Input-Output Differential (V) Min	Input-Output Differential (V) Max	Temperature Stability (%)	Quiescent Current (mA) Typ.	Operating Temperature Range (°C) Min	Operating Temperature Range (°C) Max	Output Current* (mA)	Package Type
Positive Voltage Regulators	LM100	8.5	40	2.0	30	0.1	12	0.05	0.02	3	30	1.0	1.0	−55	125	20	TO-5, Flat Pack
	LM200	8.5	40	2.0	30	0.1	12	0.05	0.02	3	30	1.0	1.0	−25	85	20	TO-5, Flat Pack
	LM300	8.5	30	2.0	20	0.1	12	0.05	0.02	3	20	2.0	1.0	0	70	20	TO-5, Flat Pack
	LM105	8.5	50	4.5	40	0.02	12	0.015	0.003	3	30	1.0	0.8	−55	125	20	TO-5, Flat Pack
	LM205	8.5	50	4.5	40	0.02	12	0.015	0.003	3	30	1.0	0.8	−25	85	20	TO-5, Flat Pack
	LM305	8.5	40	4.5	30	0.02	12	0.015	0.003	3	30	1.0	0.8	0	70	20	TO-5, Flat Pack
	LM305A	8.5	50	4.5	40	0.02	45	0.015	0.003	3	30	1.0	0.8	0	70	45	TO-5
	LM376	9.0	40	5.0	37	0.2 max	25	0.03 max	0.1 max	3	30	–	2.5 max	0	70	25	Molded DIP
	LM723	9.5	40	2.0	37	0.03	50	0.01	0.02	3	38	0.015%/°C	1.3	−55	125	150	TO-5, Cavity DIP
	LM723C	9.5	40	2.0	37	0.03	50	0.01	0.02	3	38	0.015%/°C	1.3	0	70	150	TO-5, Cavity & Molded DIP
Negative Voltage Regulators	LM104	−50	−8	−40	−15 mV	0.01	20	.05	0.01	2	50	1.0	3.6	−55	125	20	TO-5, Flat Pack
	LM204	−50	−8	−40	−15 mV	0.01	20	.05	0.01	2	50	1.0	3.6	−25	85	20	TO-5, Flat Pack
	LM304	−40	−8	−30	−15 mV	0.01	20	.05	0.01	2	40	1.0	3.6	0	70	20	TO-5, Flat Pack
	LM723	−40	−9.5	−37	−2	0.03	50	0.01	0.02	3	38	0.015%/°C	1.3	−55	125	150	TO-5, Cavity & Molded DIP
	LM723C	−40	−9.5	−37	−2	0.03	50	0.01	0.02	3	38	0.015%/°C	1.3	0	70	150	TO-5, Cavity & Molded DIP

Note: The maximum power dissipation for the LM100, LM105 and LM104 regulators is 800 mW. For most cases of the LM100, LM105 and the LM104, output current will be limited by maximum junction temperature and thermal resistance as indicated.

Package	Thermal Resistance Junction to Air	Thermal Resistance Junction to Case
TO-5	150°C/W	45°C/W
Flat Pack	185°C/W Mounted	
Solid Kovar TO-5	150°C/W	15°C/W
TO-3	35°C/W	1.5°C/W

*The output currents given, as well as the load regulation for the LM100, LM105, LM723 and LM104 family of regulators can be increased by the addition of external transistors. The increase will be roughly equal to the composite current gain of the added transistors.

Variable Voltage Regulator Guide

Voltage Comparator Guide

Device	Temperature Range*	DTL/TTL Fanout	Supply Voltage Typ (Volts)	Input Bias Current (+25°C) Max (μA)	Input Offset Current (+25°C) Max (μA)	Input Offset Voltage (+25°C) Max (mV)	Response Time† Typ (ns)	Voltage Gain Typ	Package Type	Comments
LM106	Military	10	$V^+ = +12$	20	3	2	40 max	40k	TO-5 F.P.	
LM206	Industrial	10	$V^- = -3$	20	3	2	40 max	40k	TO-5 F.P.	Single comparator with strobe, high speed and sensitivity, large fanout.
LM306	Commercial	10	To −12	25	5	5	40 max	40k	TO-5 F.P.	
LM111 LH2111 (Note 1)	Military	5	±15	.1	.04	.7	200	200k	TO-5 DIP F.P.	
LM211 LH2211 (Note 1)	Industrial	5	To +5	.1	.04	.7	200	200k	TO-5 DIP F.P.	Single, with strobe, will work from single supply, low bias current.
LM311 LH2311 (Note 1)	Commercial	5	And GND	.25	.06	2	200	200k	TO-5 DIP F.P.	
LM119	Military	2 (each side)	±15	.5	.075	4	80	40k	TO-5 DIP F.P.	
LM219	Industrial	2 (each side)	To +5	.5	.075	4	80	40k	TO-5 DIP F.P.	High speed dual comparator.
LM319	Commercial	2 (each side)	And GND	1	.2	8	80	40k	TO-5 DIP	
LM139	Military	1	±1	.1	.025	5	1.3 μs	200k	DIP F.P.	
LM239	Industrial	1	To ±18	.25	.050	5	1.3 μs	200k	DIP	Quad comparator designed for single supply operation; input common mode range includes ground.
LM339	Commercial	1	Or From	.25	.050	5	1.3 μs	200k	DIP	
LM139A	Military	1	+2	.1	.025	2	1.3 μs	200k	DIP F.P.	
LM239A	Industrial	1	To +36	.25	.050	2	1.3 μs	200k	DIP	Low offset voltage Quad comparator with DTL/TTL logic levels.
LM339A	Commercial	1	And GND	.25	.050	2	1.3 μs	200k	DIP	
LM160	Military	2	±4.5	10	2	2	16	3k	TO-5 DIP F.P.	
LM260	Industrial	2	To	10	2	2	16	3k	TO-5 DIP	Very high speed, outputs compatible with DTL/TTL logic levels.
LM360	Commercial	2	±6.5	15	4	4	16	3k	TO-5 DIP	
LM161	Military	2	±5	10	2	2	12	3k	TO-5 DIP F.P.	
LM261	Industrial	2	To ±15	10	2	2	12	3k	TO-5 DIP	Very high speed, with individual strobes, DTL/TTL compatible.
LM361	Commercial	2	And +5	15	4	4	12	3k	TO-5 DIP	
LM710	Military	1	$V^+ = +12$	20	3	2	40	1750	TO-5	Single, differential in, single output.
LM710C	Commercial	1	$V^- = -6$	25	5	5	40	1500	TO-5 DIP	
LM711	Military	1	$V^+ = +12$	75	10	3.5	40	1500	TO-5	Dual differential, common output, individual strobes.
LM711C	Commercial	1	$V^- = -6$	100	15	5	40	1500	TO-5 DIP	
LM1514	Military	1	$V^+ = +14$	20	3	3	30	1250	DIP	Dual LM710 with separate strobes, individual outputs.
LM1414	Commercial	1	$V^- = -7$	25	5	4	30	1000	DIP	

*Military: −55°C to +125°C
Industrial: −25°C to +85°C
Commercial: 0°C to +70°C

†Response time is specified for 100 mV step input with 5 mV overdrive.

Note 1: Dual version of device.

DATA COMMUNICATION CIRCUITS

LINE DRIVERS DEVICE NO.	LINE RECEIVERS DEVICE NO.	DESCRIPTION	POWER SUPPLY	COMMENTS
LM1488/LM1588	LM1489A/LM1589A (quad) or DM7822/DM8822 (dual)	Communication to EIA standard RS 232C.	±12V LM1489A & DM7822 +5V only.	Twisted pair single ended. Unidirectional
DM7830/DM8830	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	True differential. ±15 volt common mode rejection. Unidirectional. Use of internal receiver termination recommended up to 100 feet.
DM7831/DM8831	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	True differential, bidirectional. Driver includes upper and lower level clamps to combat transients. Use of internal receiver termination optional.
DM7832/DM8832	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	As above, but without upper level clamping, so party line buses may be used, even with some peripherals powered down.
DM7831/DM8831	DM7837/DM8837 (hex) or DM7836/DM8836 (quad)	Quad single-ended line driver and hex receiver, or a quad 2 input NOR receiver.	+5V	If used unidirectionally, receiver should be terminated. In party line applications disabled driver clamps line. Receiver input current is 15 μA typical, has no hysteresis.
LM75109	LM75107A	Dual differential line driver and receiver.	±5V	May be used in party-line or data-bus systems.
LM75110	LM75108A	Dual differential line driver and receiver.	±5V	May be used in party-line or data-bus systems.

TRANSCEIVER DEVICE NO.	DESCRIPTION	POWER SUPPLY	COMMENTS
DM7838/DM8838	Quad open collector transceiver.	+5V	Receiver has typical 15 μA input current one-volt hysteresis. Driver will pull down double terminated 120Ω line.
DM7839/DM8839	Quad TRI-STATE™ transceiver. Four transmitters all disabled by control NOR gate.	+5V	Drivers have 10.4 mA forward drive at 2.4V, sink 32 mA at 0.4 volts. Receivers have 1 volt hysteresis, input current is 15 μA typical. Disabled driver clamps undershoots. A transceiver on the bus may be powered down without affecting bus logic levels.
DM7833/DM8833	Quad TRI-STATE transceiver. One control disables all transmitters; one control disables all receiver outputs.	+5V	
DM7834/DM8834	Quad TRI-STATE transceiver. Controls same as DM7839 but driver and receiver are inverting.	+5V	
DM7835/DM8835	Quad TRI-STATE transceiver. Controls same as DM7833 but driver and receiver are inverting.	+5V	

SENSE AMPLIFIER CIRCUITS

The core sense amplifiers are monolithic circuits comprising a reference amplifier and two sense channels. The output circuit changes state when the absolute difference in input voltage to the sense amp exceeds the absolute difference in voltage applied to the reference amplifier (threshold voltage). These parts with even numbers have a tighter guaranteed input threshold uncertainty.

DEVICE NO.	OUTPUT FORM	COMMENTS
LM7520, LM7521	AND-OR common output and complement	By coupling back complement output to true gate, latch may be formed. Set by (Strobe A. Memory A + Strobe B. Memory B) reset by complement gate.
LM7522, LM7523	AND-OR-INVERT common output high current open collector	Convenient for wire-OR'ed memory expansion.
LM7524, LM7525	An AND gate for each independent channel	Separate channels for small memories.
LM7534, LM7535	Open collector NAND gate for each independent channel	Convenient—for wire-OR'ed memory expansion in small memories. Useful for direct setting of flip flop.
LM7528, LM7529	AND gate, plus test point for each sense amp	
LM7538, LM7539	NAND gate, plus test point for each sense amp	

PERIPHERAL DRIVERS

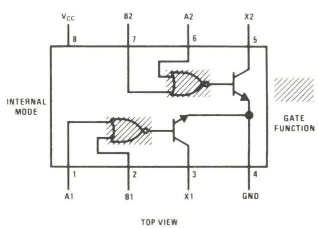
The peripheral drivers are dual monolithic circuits, each consisting of a logic gate and a large geometry NPN transistor. The transistor is guaranteed to sink 300 mA and to hold off collector voltage of 30 volts even when powered down.

DEVICE NO.	GATE FUNCTION	MODE OF CONNECTION	NO. OF PINS
LM350	NOR	External	14
LM351 (LM75453)	NOR	Internal	8
LM75450	NAND	External	14
LM75451	NAND	Internal	8
LM75454	NOR	Internal	8

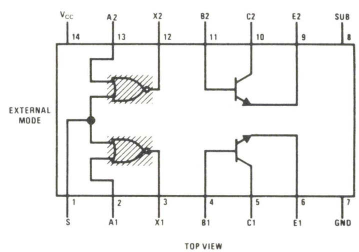
MEMORY DRIVERS

DEVICE NO.	OUTPUT FORM	COMMENTS
LM55324, LM75324	AND gate decoding to two sink and two source output transitors	High Current output transistors; single timing input control
LM55325, LM75325	NAND gate decoding to two sink and two source output transistors	Separate strobe control for sink and source output devices

PERIPHERAL DRIVER CONNECTION DIAGRAMS

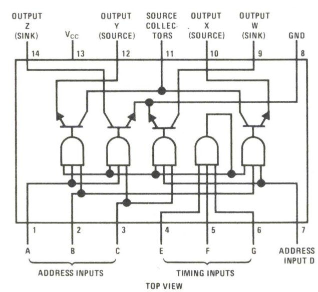


LM351(LM75453), LM75451,LM75452,LM75454

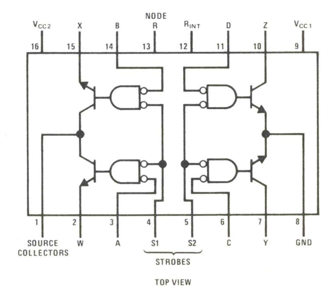


LM350,LM75450

MEMORY DRIVER CONNECTION DIAGRAMS



LM55324/LM75234



LM55325/LM75325

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Analog Devices		
AD503-(J, K)	TO-5	LH0042C pin for pin
AD503-(S)	TO-5	LH0042 pin for pin
AD506-(J, K)	TO-5	LH0022C pin for pin
AD506-(S)	TO-5	LH0022C* pin for pin
AD511	MOD	LH0042C
AD513-(J, K)	TO-5	LH0042C* pin for pin
AD513-(S)	TO-5	LH0042* pin for pin
AD516-(J, K)	TO-5	LH0022C* pin for pin
AD516-(S)	TO-5	LH0022* pin for pin
ADP517	MOD	LH0042C
M501-(A, B, C,)	TO-8	LH0022C
40-(J, K,)	TO-8	LH0042C
41-(J, K, L)	MOD	LH0052C
42-(J, K, L)	MOD	LH0052C
43-(J)	MOD	LH0022C
44-(J, K)	MOD	LH0062C
45-(J, K)	MOD	LH0062C
142-(A, B, C)	MOD	LH0042C
146-(J, K)	MOD	LH0022C
149-(J, K)	MOD	LH0062C

*These amps use feedforward compensation to boost slew rate. For true high slew rate amp see LH0062/LH0062C.

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Bell and Howell		
20-008	MOD	LH0042C
20-108	MOD	LH0042C
20-208	TO-8	LH0022
20-248	TO-8	LH0022C
Burr-Brown		
3307/12C	MOD	LH0042C
3308/12C	MOD	LH0042C
3312/12C	MOD	LH0042C
3313/12C	MOD	LH0042C
3341/15C	MOD	LH0032C
3342/15C	MOD	LH0032C
3348/03	MOD	LH0052C
3349/03	MOD	LH0026C
3350/03	MOD	LH0042C
3400-(A, B)	MOD	LH0032C
3401-(A, B)	MOD	LH0062C
3402-(A, B)	MOD	LH0062C
3403-(A, B)	MOD	LH0042C
3420-(J, K, L)	MOD	LH0052C
3421-(J, K, L)	MOD	LH0052C

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Fairchild		
U5B7740312 (μA740)	TO-5	LH0042 pin for pin
U5B7740393 (μA740C)	TO-5	LH0042C pin for pin
Intech		
A100	MOD	LH0042C
A101	MOD	LH0042C
A102	MOD	LH0022C
A103	MOD	LH0022C
A122	MOD	LH0052
A123	MOD	LH0052
A125	MOD	LH0052C
A130	MOD	LH0062C
A131	MOD	LH0062C
A136	MOD	LH0062C
A137	MOD	LH0062C
A148-(A, B, C)	MOD	LH0042C
A1026	MOD	LH0022C
A1027	MOD	LH0022C
Intersil		
ICH8500	TO-5	LH0052 pin for pin
ICH8500A	TO-5	LH0052 pin for pin
ICH8500C	TO-5	LH0052C pin for pin
ICL8007C	TO-5	LH0042C pin for pin
ICL8007M	TO-5	LH0042 pin for pin
ICL8007AM	TO-5	LH0042 pin for pin
ICL8007AC	TO-5	LH0042C pin for pin
OEI		
9714	MOD	LH0042C
9715	MOD	LH0062C
9716	MOD	LH0042C
9717	MOD	LH0042C
9718	MOD	LH0062C
9720	MOD	LH0032C
9721	MOD	LH0042C
9723	MOD	LH0032C
Signetics		
SU536T	TO-5	LH0042C pin for pin
SU740C	TO-5	LH0042C pin for pin

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Siliconix		
L120A	TO-5	LH0042
L120C	TO-5	LH0042C
L137AA	TO-5	LH0022
L137CA	TO-5	LH0022C
Teledyne Semiconductor (Amelco)		
2404BG	TO-8	LH0042C
2405BG	TO-8	LH0042C
2709BG	TO-8	LH0042C
2809BG	TO-8	LH0042C
2740BE	TO-5	LH0042C
2841BE	TO-5	LH0042C
2741BF	TO-8	LH0042C
2741BH	TO-8	LH0042C
Teledyne Nexus Phillrick		
QFT	MOD	LH0042C
QFT	MOD	LH0042C
QFT-2B	MOD	LH0052C
QFT-5	MOD	LH0042C
QFT-5	MOD	LH0042C
Q25AH	TO-8	LH0042C
PP25A	MOD	LH0042C
1003	MOD	LH0052C
100301	MOD	LH0052C
1006	MOD	LH0042C
1008	MOD	LH0042C
1009	MOD	LH0042C
100901	MOD	LH0042C
100902	MOD	LH0042C
1011	MOD	LH0062C
101101	MOD	LH0062C
101102	MOD	LH0062C
1019	MOD	LH0032C
1021	MOD	LH0022C
1023	MOD	LH0052C
102301	MOD	LH0052C
1025	MOD	LH0032C
1408	MOD	LH0052C
140801	MOD	LH0052C
140802	MOD	LH0052C
140810	TO-8	LH0052C
1402	TO-8	LH0042C
140201	TO-8	LH0042C
140202	TO-8	LH0042C
1407	TO-8	LH0042C
140701	TO-8	LH0042C
1414	MOD	LH0062C
141410	DIP	LH0062C
1421	TO-5	LH0042C

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Zeltex		
ZA801-(D1, E1)	DIP	LH0042C
ZA801-(M1, M2)	DIP	LH0042C
ZA801-(M3)	DIP	LH0022C
ZA801-(T1)	TO-8	LH0042C
ZA802-(M1, M2)	MOD	LH0022C
ZA803-(M1)	MOD	LH0052C
ZA804-(M1, M2)	MOD	LH0042C
ZA903-(M1, M2)	MOD	LH0052C
133	MOD	LH0022C
133-03	MOD	LH0052C
133-04	MOD	LH0022C
134	MOD	LH0042C
134D	MOD	LH0042C
135	MOD	LH0062C

FET OP AMP Cross Reference

TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
SN5500F		LM5524J
SN5510F		LM733H
SN5510L		LM733H
SN5511F		LM733H
SN5511L		LM733H
SN5524J	LM5524J	
SN5525J	LM5525J	
SN7500F		LM7524J
SN7501F		LM7524J
SN7502F		LM7524J
SN7510F		LM733CH
SN7510L		LM733CH
SN7511L		LM733CH
SN7520J	LM7520J	
SN7520N	LM7520N	
SN7521J	LM7521J	
SN7521N	LM7521N	
SN7522J	LM7522J	
SN7522N	LM7522N	
SN7523J	LM7523J	
SN7523N	LM7523N	
SN7524J	LM7524J	
SN7524N	LM7524N	
SN7525J	LM7525J	
SN7525N	LM7525N	
SN7528J	LM7528J	
SN7528N	LM7528N	
SN7529J	LM7529J	
SN7529N	LM7529N	
SN52101AJ	LM101AD	
SN52101AL	LM101AH	
SN52101AZ	LM101AF	
SN52107J	LM107D	
SN52107L	LM107H	
SN52107Z	LM107F	
SN52558L	LM1558H	
SN52702AF		LM101AF
SN52702AL		LM101AH
SN52702AN		LM301AN
SN52702F		LM101AF
SN52702L		LM101AH
SN52702N		LM301AN
SN52702Z		LM101AF
SN52709AF		LM709AH
SN52709AL	LM709AH	
SN52709AN		LM709AH
SN52709F		LM709H
SN52709L	LM709H	
SN52709N		LM709H
SN52710J		LM710H
SN52710L	LM710H	
SN52710N		LM710H
SN52710S		LM710H
SN52711J		LM711H
SN52711L	LM711H	

TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
SN52711N		LM711H
SN52711S		LM711H
SN52733L	LM733H	
SN52741J	LM741D	
SN52741L	LM741H	
SN52741Z	LM741F	
SN52747J	LM747D	
SN52747Z	LM747F	
SN52748J		LM748H
SN52748L	LM748H	
SN52748Z		LM748H
SN52770J		LM108D
SN52770L		LM108H
SN52770Z		LM108F
SN52771J		LM112D
SN52771L		LM112H
SN52771Z		LM112F
SN55107J	LM55107J	
SN55108J	LM55108J	
SN55109J	LM55109J	
SN55110J	LM55110J	
SN55182J	DM7820AJ	
SN55183J	DM7830J	
SN56514L		LM1496H
SN72301AJ	LM301AD	
SN72301AL	LM301AH	
SN72301AN		LM301AN
SN72301AP	LM301AN	
SN72301AZ	LM301AF	
SN72307J	LM307D	
SN72307L	LM307H	
SN72307N	LM307N	
SN72307P		LM307H
SN72307Z	LM307F	
SN72558L	LM1458H	
SN72558P	LM1458N	
SN72702F		LM301AF
SN72702L		LM301AH
SN72702N		LM301AN
SN72709L	LM709CH	
SN72709N	LM709CN	
SN72709P		LM709CN
SN72709S		LM709CH
SN72710J		LM710CN
SN72710L	LM710CH	
SN72710N	LM710CN	
SN72710S		LM710CH
SN72711J		LM711CN
SN72711L	LM711CH	
SN72711N	LM711CN	
SN72811S		LM711CH
SN72720N	LM1414N	
SN72733L	LM733CH	
SN72733N	LM733CN	
SN72741J	LM741CD	

TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
SN72741L	LM741CH	
SN72741N	LM741CN-14	
SN72741P	LM741CN	
SN72741Z	LM741CF	
SN72747J	LM747CD	
SN72747N	LM747CN	
SN72748N		LM748CN
SN72748P	LM748CN	
SN72748J		LM748CN
SN72748L	LM748CH	
SN72748Z		LM748H
SN72770J		LM308D
SN72770L		LM308H
SN72770N		LM308H
SN72770P		LM308H
SN72770Z		LM308F
SN72771L		LM312H
SN72771N		LM312D
SN72771P		LM312D
SN72771Z		LM312F
SN75100L		DM8820D
SN75107J	LM75107J	
SN75107N	LM75107N	
SN75108J	LM75108J	
SN75108N	LM75108N	
SN75109J	LM75109J	
SN75109N	LM75109N	
SN75110J	LM75110J	
SN75110N	LM75110N	
SN75150J		DM8830J
SN75150N		DM8830N
SN75105P		DM8830N
SN75182J	DM8820AJ	
SN75182N	DM8820AN	
SN75183J	DM8830J	
SN75183N	DM8830N	
SN75324J	LM75324J	
SN75324N	LM75324N	
SN75325J	LM75325J	
SN75325N	LM75325N	
SN75450N	LM75450N	
SN75450AN	LM75450N	
SN75451P	LM75451N	
SN75451AP	LM75451N	
SN75452P	LM75452N	
SN75453P	LM75453N	
SN75454P	LM75454N	
SN75460	LM75460N	
SN75461	LM75461N	
SN75462	LM75462N	
SN75463	LM75463N	
SN75464	LM75464N	
SN76514L		LM1496H
SN76514N		LM1496H

MOTOROLA DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
MC1303L		LM1303N
MC1304P	LM1304N	
MC1305P	LM1305N	
MC1306P		LM380N
MC1307P	LM1307N	
MC1326P		LM3067N
MC1326PQ		LM3067N
MC1328G		LM3067N
MC1328P		LM3067N
MC1328PQ		LM3067N
MC1350P		LM703L
MC1351P	LM1351N	
MC1358P		LM3065N
MC1358PQ		LM3065N
MC1380P		LM380N
MC1410G		LM733CH
MC1414L	LM1414J	
MC1420G		LM733CH
MC1430F		LM301AF
MC1430G		LM301AH
MC1430P		LM301AN
MC1431F		LM301AF
MC1431G		LM301AH
MC1431P		LM301AN
MC1433F		LM301AF
MC1433G		LM301AH
MC1433L		LM301AN
MC1435F		LM1303N
MC1435G		LM1303N
MC1435L		LM1303N
MC1436CG	LM1436H	
MC1436G	LM1436H	
MC1437L		LM1458N-14
MC1437P		LM1458N-14
MC1438R		LH0002H
MC1439G		LM301AH
MC1439L		LM301AH
MC1439P2		LM301AH
MC1440F		LM7524J
MC1440G		LM7524J
MC1440L		LM7524J
MC1441F		LM7524J
MC1441L		LM7524J
MC1454G		LM380H
MC1456CG		LM308H
MC1456G		LM308H
MC1458CG	LM1458H	
MC1458CL		LM1458N-14
MC1458CP1	LM1458N	
MC1458CP2	LM1458N-14	
MC1458G	LM1458H	
MC1458L		LM1458N-14
MC1458P1	LM1458N	
MC1458P2	LM1458N-14	
MC1460G		LM305H
MC1460R		LM305H
MC1461G		LM305H
MC1461R		LM305H
MC1463G		LM304H
MC1463R		LM304H
MC1466L		LM304H
MC1469G		LM305H
MC1469R		LM305H

MOTOROLA DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
MC1488L	LM1488J	
MC1489AL	LM1489AJ	
MC1489L	LM1489J	
MC1496G	LM1496H	
MC1496L	LM1496N	
MC1509F		LM733H
MC1510F		LM733H
MC1510G		LM733H
MC1514L	LM1514J	
MC1519G		LM733H
MC1520F		LM733H
MC1520G		LM733H
MC1530F		LM101AF
MC1530G		LM101AH
MC1531F		LM101AF
MC1531G		LM101AH
MC1533F		LM101AF
MC1533G		LM101AH
MC1533L		LM101AD
MC1535F		LM1303N
MC1535G		LM1303N
MC1536G	LM1536H	
MC1537L		LM1458N-14
MC1538R		LH0002H
MC1539G		LM101AH
MC1539L		LM101AD
MC1504F		LM5524J
MC1540G		LM5524J
MC1540L		LM5524J
MC1541F		LM5524J
MC1541L		LM5524J
MC1550F		LM171H
MC1550G		LM171H
MC1552G		LM733H
MC1553G		LM733H
MC1554G		LM380N
MC1556G		LM108H
MC1558G	LM1558H	
MC1558L	LM1558D	
MC1560G		LM105H
MC1560R		LM105H
MC1561G		LM105H
MC1561R		LM105H
MC1563G		LM104H
MC1563R		LM104H
MC1566L		LM104H
MC1569G		LM105H
MC1569R		LM105H
MC1580L		DM7831J
MC1582L		DM7830J
MC1583L		DM7820J
MC1584L		DM7820AJ
MC1590G		LM170H
MC1596G	LM1596H	
MC15961		LM1596H
MC1709CF		LM709CH
MC1709CG	LM709CH	
MC1709CL		LM709CN
MC1709CP1	LM709CN	
MC1709CP2		LM709CN
MC1709F		LM709H
MC1709G	LM709H	
MC1709L		LM709H

MOTOROLA DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
MC1710CF		LM710CH
MC1710CG	LM710CH	
MC1710CL		LM710CH
MC1710F		LM710H
MC1710G	LM710H	
MC1710L		LM710H
MC1711CF		LM711CH
MC1711CG	LM711CH	
MC1711CL		LM711CH
MC1711F		LM711H
MC1711G	LM711H	
MC1711L		LM711H
MC1712CF		LM733CH
MC1712CG		LM733CH
MC1712CL		LM733CH
MC1712F		LM733H
MC1712G		LM733H
MC1712L		LM733H
MC1723CG	LM723CH	
MC1723CL	LM723CD	
MC1723G	LM723H	
MC1723L	LM723D	
MC1733CG	LM733CH	
MC1733CL	LM733CD	
MC1733G	LM733H	
MC1733L	LM733D	
MC1741CF	LM741CF	
MC1741CG	LM741CH	
MC1741CL		LM741CH
MC1741CP1	LM741CN	
MC1741CP2	LM741CN-14	
MC1741F	LM741F	
MC1741G	LM741H	
MC1741L	LM741D	
MC1748CG	LM748CH	
MC1748G	LM748H	
MFC40000D		LM380N
MFC4010A		LM381N
MFC4050		LM380N
MFC4060		LM376N
MFC6010		LM2111N
MFC6030		LM376N
MFC6070		LM380N
MFC8000		LM703LN
MFC8001		LM703LN
MFC8002		LM703LN
MFC8010		LM380N
MFC8030		LM703LN
MFC8040		LM381N
MFC9020		LM380N
MLM101AG	LM101AH	
MLM105G	LM105H	
MLM107G	LM107H	
MLM109K	LM109K	
MLM201AG	LM201AH	
MLM205G	LM205H	
MLM207G	LM207H	
MLM209K	LM209K	
MLM301AG	LM301AH	
MLM305G	LM305H	
MLM307G	LM307H	
MLM309K	LM309K	

SIGNETICS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	SIGNETICS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	SIGNETICS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
N5201A		LM301AD	NE510A		LM371H	S5558T	LM1558H	
N5307T	LM307H		NE510J		LM371H	S5596K	LM1596H	
N5308T	LM308H		NE515A		LM733CN	S5709T	LM709H	
N53A1T	LM301AH		NE515G		LM733CH	S5710T	LM710H	
N53A1V	LM301AN		NE515K		LM733CH	S5711K	LM711H	
N53A8T	LM308AH		NE518A		LM306H	S5711T		LM711H
N5556V		LM307N	NE518G		LM306H	S5723L	LM723H	
N5558F	LM1458N		NE518K		LM306H	S5733F	LM733D	
N5558T	LM1458H		NE526A		LM306H	S5733K	LM733H	
N5596K	LM1496H		NE526G		LM306H	S5740T	LM740H	
N5596K		LM1496N	NE526K		LM306H	S5741T	LM741H	
N5709A	LM709CN		NE529K	LM361H		S5747K	LM747H	
N5709T	LM709CH		NE529A	LM361N		S5748T	LM748H	
N5709V		LM709CN	NE531G		LM318H	SE501G		LM733H
N5710A	LM710CN		NE531T		LM318H	SE501K		LM733H
N5710T	LM710CH		NE531V		LM318H	SE510A		LM171H
N5711A	LM711CN		NE533G		LM4250CH	SE510J		LM171H
N5711K	LM711CH		NE533T		LM4250CH	SE515G		LM733H
N5723A	LM723CN		NE533V		LM4250CH	SE515K		LM733H
N5723L	LM723CH		NE536T		LM316H	SE518A		LM106H
N5733A	LM733CN		NE537G		LM308H	SE518G		LM106H
N5733K	LM733CH		NE537T		LM308H	SE518K		LM106H
N5740T	LH740CH		NE540L		LH0021CK	SE526A		LM106H
N5741A	LM741CN-14		NE550A		LM723CH	SE526G		LM106H
N5741T	LM741CH		NE550L		LM723CH	SE526K		LM106H
N5741V	LM741CN		NE555V	LM555CN		SE529K	LM161H	
N5747A	LM747CN		NE555T	LM555CH		SE531G		LM118H
N5747F	LM747CD		NE565A	LM565CN		SE533G		LM4250CH
N5747K	LM747CH		NE565K	LM565CH		SE533T		LM4250H
N5748A		LM748CH	NE566T	LM566CH		SE537G		LM108H
N5748T	LM748CH		NE566V	LM566CN		SE537T		LM108H
N5748V	LM748CN		NE567T	LM567CH		SE540L		LH0021K
N7520B	LM7520N		NE567V	LM567CN		SE550L		LM723H
N7521B	LM7521N		PA239A		LM381N	SE555T	LM555H	
N7522B	LM7522N		S5101T	LM101H		SE555V	LM555N	
N7523B	LM7523N		S5107T	LM107H		SE565K	LM565H	
N7524B	LM7524N		S5108T	LM108H		SE566T	LM566H	
N7525B	LM7525N		S51A1T	LM101AH		SE567T	LM567H	
NE501A		LM733CN	S51A8T	LM108AH		SU536G		LM216H
NE501G		LM733CH	S5556L		LM107H	SU536T		LM216H
NE501K		LM733CH						

Linear Cross Reference Guide

FAIRCHILD DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
U3F7101311 [UA101AF]	LM101AF	
U3F7101333 [UA201AF]	LM201AF	
U3F7702312		LM101AF
U3F7702313		LM101AF
U3F7709311		LM709AH
U3F7709312		LM709H
U3F7709313		LM709H
U3F7710312		LM710AH
U3F7710313		LM710CH
U3F7711312		LM711H
U3F7711313		LM711H
U3F7733312		LM733H
U3F7733313		LM733H
U3F7741312	LM741F	
U3F7741313	LM741F	
U3F7748312	LM101AF	
U3F7748313	LM201AF	
U3I962051X		DM7820D
U3I962059X		DM8820N
U3I962151X		DM7830D
U3I962159X		DM8830N
U3I962251X		DM7820D
U3I962259X		DM8820N
U3M7722333		LMDAC-01
U3M7722334		LMDAC-01
U4L961451X		DM7830D
U4L961459X		DM8830D
U4L961551X		DM7820D
U4L961559X		DM8820N
U4L961651X		LM1488N
U4L961659X		LM1488N
U4L961751X		LM1489AN
U4L961759X		LM1489AN
U5A7064394 [UA3064]	LM3064H	
U5B7101312 [UA101H]	LM101H	
U5B7101311 [UA101AH]	LM101AH	
U5B7101333 [UA201AH]	LM201AH	
U5B7101392 [UA301AH]	LM301AH	
U5B7201393 [UA201H]	LM201H	
U5B7702312		LM101AH
U5B7702393		LM301AH
U5B7709311	LM709AH	
U5B7709312	LM709H	
U5B7709393	LM709CH	
U5B7710312	LM710AH	
U5B7710393	LM710CH	
U5B7716393		LM380N
U5B7730312		LM114AH
U5B7730393		LM114H
U5B7735312		LM4250H
U5B7735333		LM4250H
U5B7735393		LM4250CH
U5B7740312		LH740AH
U5B7740393		LH740AC
U5B7741312	LM741H	
U5B7741393	LM741CH	
U5B7748312	LM748H	
U5B7748393	LM748CH	
U5B7749394		LM1303N
U5B7776312	LM4250H	
U5B7776393	LM4250CH	
U5B7777312	LM101AH	

FAIRCHILD DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
U5B7777393	LM301AH	
U5D7703312		LM703LH
U5D7703393	LM703LH	
U5E7064394 [UA3064]	LM3064H	
U5E7746394		LM746CN
U5E7754393		LM3065N
U5E7796312	LM1596H	
U5E7796393	LM1496H	
U5F7711312	LM711H	
U5F7711393	LM711CH	
U5F7715312		LM118H
U5F7715393		LM318H
U5F7719312		LM273H
U5F7719393		LM373H
U5F7733312	LM733H	
U5F7733393	LM733CH	
U5F7734312		LM111H
U5F7734393		LM311H
U5F7747312	LM747H	
U5F7747393	LM747CH	
U5R7723312	LM723H	
U5R7723393	LM723CH	
U5T7725311		LM725AH
U5T7725312		LM725H
U5T7725333		LM725H
U5T7725393		LM725CH
U5U7726312		LM114A
U5U7726323		LM114H
U5U7727312		LH1725H
U5U7727333		LH1725H
U5Z7703394		LM703LH
U6A7065394 [UA3065]	LM3065N	
U6A7101311 [UA101AD]	LM101AD	
U6A7101312 [UA101D]	LM101D	
U6A7101333 [UA201AD]	LM201AD	
U6A7101393 [UA301AD]	LM301AD	
U6A7201393 [UA201D]	LM201D	
U6A7702312		LM101AD
U6A7702393		LM301AD
U6A7709311		LM709AH
U6A7709312		LM709H
U6A7709393	LM709CN	
U6A7710312		LM710AH
U6A7710393	LM710CN	
U6A7711312		LM711H
U6A7711393	LM711CN	
U6A7715312		LM118D
U6A7715393		LM318D
U6A7723312	LM723D	
U6A7723393	LM723CD	
U6A7729394	LM1304N	
U6A7732394	LM1305N	
U6A7733312	LM733D	
U6A7733393	LM733CD	
U6A7739312		LM1303D
U6A7739393		LM1303N
U6A7741312	LM741D	
U6A7741393	LM741CN-14	
U6A7746394	LM746CN	
U6A7748312	LM101AD	
U6A7748393	LM301AD	
U6A7749312		LM1303N

FAIRCHILD DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
U6A7749393		LM1303N
U6A7750312		LM111H
U6A7750393		LM311H
U6A7754394		LM3065N
U6A7757312		LM374H
U6A7757393		LM374H
U6A7760312	LM160J	
U6A7777312	LM101AD	
U6A7767394		LM1304N
U6A7760393	LM360J	
U6A7777393	LM301AD	
U6A7781394	LM3071N	
U6A7784354		LM3065N
U6A962051X		DM7820D
U6A962059X		DM8820N
U6A962151X		DM7830D
U6A962159X		DM8830N
U6A962251X		DM7820D
U6A962259X		DM8820N
U6B7780394	LM3070N	
U6W7747312	LM747D	
U6W7747393	LM747CD	
U7A7747312	LM747D	
U7A7747393	LM747CD	
U7B7524392	LM7524J	
U7B7525393	LM7525J	
U7B7761391		LM7524J
U7B7761392	LM7524J	
U7B7761393	LM7525J	
U7B961551X		DM7820D
U7B961559X		DM8820N
U7B964451X		DH0011H
U7B961451X		DM7830D
U7B961459X		DM8830N
U7B961651X		LM1488N
U7B961659X		LM1488N
U7B961751X		LM1489AN
U7B961759X		LM1489AN
U7F7065394 [UA3065]	LM3065N	
U7F7784354		LM3065N
U9T7101393 [UA301AN]	LM301AN	
U9T7201393 [UA201T]	LM201N	
U9T7741393	LM741CN	
U9T7748393	LM748CN	
U9T7777393		LM301AN
UGH7805393	LM340K-05	
UGH7808393	LM340K-08	
UGH7812393	LM340K-12	
UGH7815393	LM340K-15	
UGH7818393	LM340K-18	
UGH7824393	LM340K-24	
UGJ7805393	LM340T-05	
UGJ7808393	LM340T-08	
UGJ7812393	LM340T-12	
UGJ7815393	LM340T-15	
UGJ7818393	LM340T-18	
UGJ7824393	LM340T-24	
UGJ7109312 [UA109K]	LM109K	
UGJ7109333 [UA209K]	LM209K	
UGJ7109393 [UA309K]	LM309K	
UXX7791312		LH0021K
UXX7791393		LH0021CK

Linear Cross Reference Guide

Voltage Regulators

LM100/LM200/LM300 voltage regulator

general description

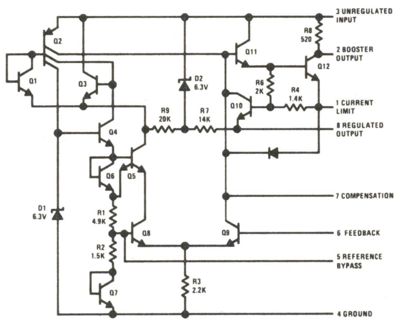
The LM100, LM200 and LM300 are integrated voltage regulators designed for a wide range of applications from digital power supplies to precision regulators for analog circuitry. Built on a single silicon chip, these devices are encapsulated in either an 8-lead, low profile TO-5 header or a 1/4 x 1/4 metal flat package. Outstanding characteristics are:

- Output voltage adjustable from 2V to 30V (LM300 adjustable from 2V to 20V)
- Better than one percent load and line regulation
- One percent temperature stability
- Adjustable short-circuit limiting
- Output currents in excess of 5A possible by adding external transistors
- Can be used as either a linear or high-efficiency switching regulator.

Additional features are fast response to both load and line transients, small standby power dissipation, freedom from oscillations with varying resistive and reactive loads, and the ability to start reliably on any load within rating.

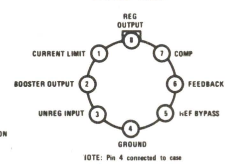
The LM100 is specified for operation over the −55°C to +125°C military temperature range. The LM200 and LM300 are low cost, commercial-industrial versions of the LM100. They are identical to the LM100 except that they are specified for operation from −25°C to 85°C and from 0°C to 70°C respectively.

schematic and connection diagrams



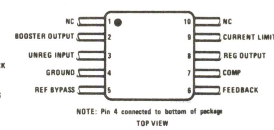
Pin connections shown are for TO-5 package

Metal Can



Order Number LM100H or LM200H or LM300H
See Package 11

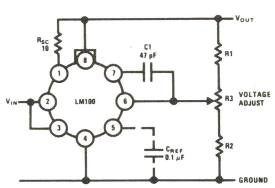
Flat Package



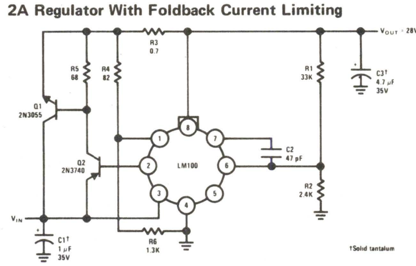
Order Number LM100F or LM200F or LM300F
See Package 3

typical applications

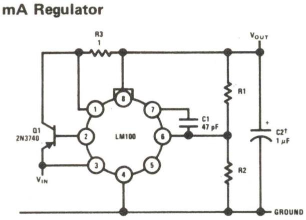
Basic Regulator Circuit



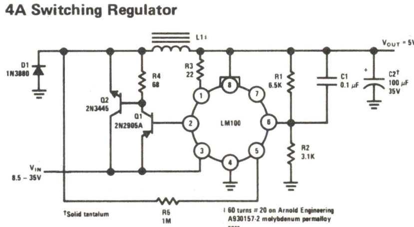
2A Regulator With Foldback Current Limiting



200 mA Regulator



4A Switching Regulator



2N 3445 2N2905

absolute maximum ratings

Input Voltage	
LM100, LM200	40V
LM300	35V
Input-Output Voltage Differential	
LM100, LM200	40V
LM300	30V
Power Dissipation (Note 1)	
LM100, LM200	800 mW
LM300	500 mW
Operating Temperature Range	
LM100, LM200	−55°C to +150°C
LM300	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range					
LM100/LM200		8.5		40	V
LM300		8.5		30	
Output Voltage Range					
LM100/LM200		2.0		30	V
LM300				20	
Output-Input Voltage Differential					
LM100/LM200		3.0		30	V
LM300				20	
Load Regulation (Note 3)	$R_{SC} = 0$, $I_O < 12$ mA		0.1	0.5	%
Line Regulation	$V_{IN} - V_{OUT} \leq 5V$		0.1	0.2	%/V
	$V_{IN} - V_{OUT} \geq 5V$		0.05	0.1	%/V
Temperature Stability					
LM100	$-55°C \leq T_A \leq +125°C$		0.3	1.0	
LM200	$-25°C \leq T_A \leq 85°C$		0.3	1.0	%
LM300	$0°C \leq T_A \leq 70°C$		0.3	2.0	
Feedback Sense Voltage		1.63	1.7	1.81	V
Output Noise Voltage	$10\ Hz \leq f \leq 10\ kHz$				
	$C_{REF} = 0$		0.005		%
	$C_{REF} = 0.1\ \mu F$		0.002		%
Long Term Stability			0.1	1.0	%
Standby Current Drain					
LM100/LM200	$V_{IN} = 40V$		1.0	3.0	mA
LM300	$V_{IN} = 30V$				
Minimum Load Current					
LM100/LM200	$V_{IN} - V_{OUT} = 30V$		1.5	3.0	mA
LM300	$V_{IN} - V_{OUT} = 20V$				

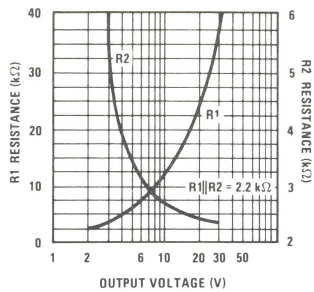
Note 1: The maximum junction temperature of the LM100 is 150°C, while that of the LM200 is 100°C, and the LM300 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. Peak dissipations to 1.0W are allowable providing the dissipation rating is not exceeded with the power averaged over a five second interval for the LM100 and LM200, and a two second interval for the LM300.

Note 2: These specifications apply for an operating temperature between −55°C to +125°C for the LM100, between −25°C to 85°C for the LM200 and between 0°C to 70°C for the LM300 devices for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 kΩ, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

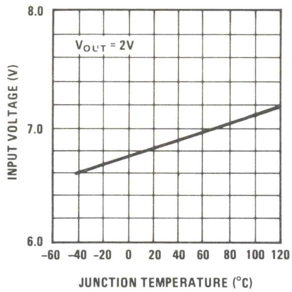
Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

typical performance characteristics

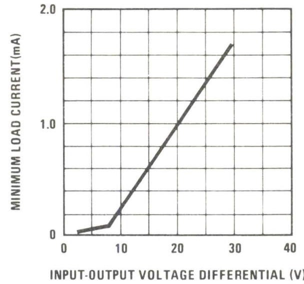
Optimum Divider Resistance Values vs Output Voltage



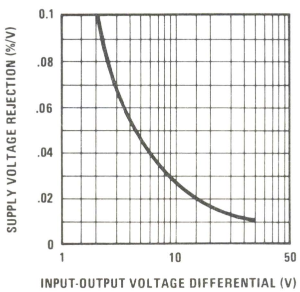
Minimum Input Voltage vs Junction Temperature



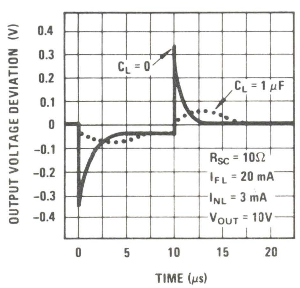
Minimum Load Current vs Input-Output Voltage Differential



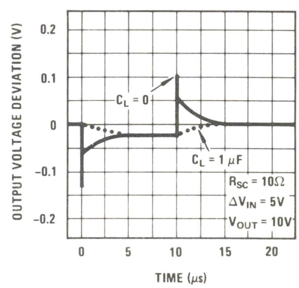
Supply Voltage Rejection vs Input-Output Voltage Differential



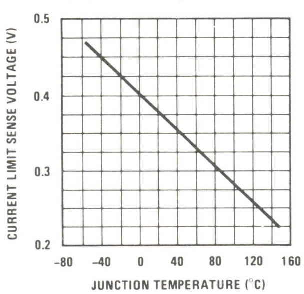
Load Transient Response



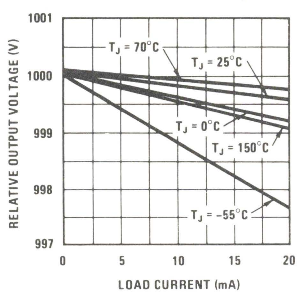
Line Transient Response



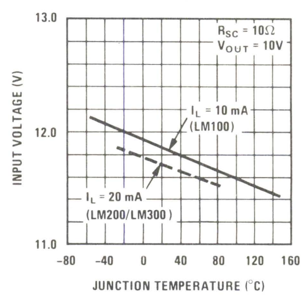
Current Limit Sense Voltage vs Junction Temperature



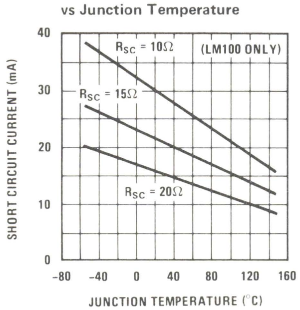
Regulation Characteristics Without Current Limiting



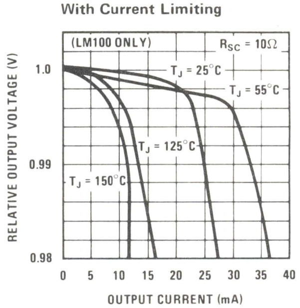
Regulator Dropout Voltage vs Junction Temperature



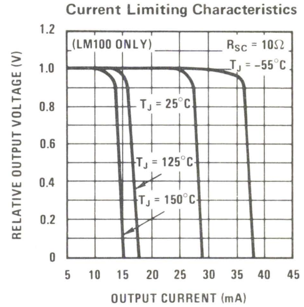
Short Circuit Current vs Junction Temperature



Regulation Characteristics With Current Limiting



Current Limiting Characteristics



Voltage Regulators

LM103 regulator diode **

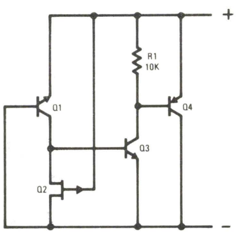
general description

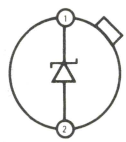
The LM103 is a two-terminal monolithic regulator diode electrically equivalent to a breakdown diode. The device makes use of the reverse punch-through of double-diffused transistors, combined with active circuitry, to produce a breakdown characteristic which is ten times sharper than single-junction zener diodes at low voltages. Breakdown voltages from 1.8V to 5.6V are available; and, although the design is optimized for operation between 100 μA and 1 mA, it is completely specified from 10 μA to 10 mA. Noteworthy features of the device are:

- Exceptionally sharp breakdown
- Low dynamic impedance from 10 μA to 10 mA
- Performance guaranteed over full military temperature range
- Planar, passivated junctions for stable operation
- Low capacitance.

The LM103, packaged in a hermetically sealed, modified TO-46 header is useful in a wide range of circuit applications from level shifting to simple voltage regulation. It can also be employed with operational amplifiers in producing breakpoints to generate nonlinear transfer functions. Finally, its unique characteristics recommend it as a reference element in low voltage power supplies with input voltages down to 4V.

schematic and connection diagrams



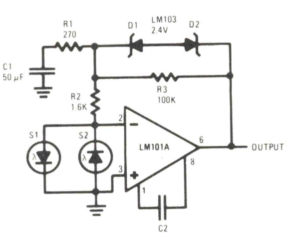


NOTE: Pin 2 connected to case.
TOP VIEW

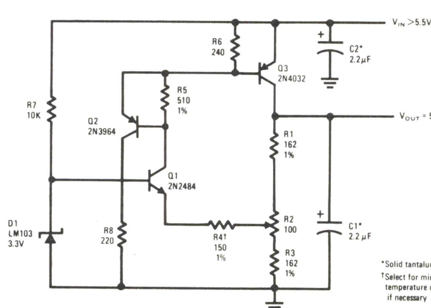
Order Number LM103H
See Package 8

typical applications

Saturating Servo Preamplifier with Rate Feedback



200 mA Positive Regulator



*Solid tantalum
†Select for minimum temperature drift, if necessary

**Covered by U.S. Patent Number 3,571,630

absolute maximum ratings

Power Dissipation (note 1)	250 mW
Reverse Current	20 mA
Forward Current	100 mA
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 60 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Reverse Breakdown Voltage Change	$10\ \mu A \leq I_R \leq 100\ \mu A$		60	120	mV
	$100\ \mu A \leq I_R \leq 1$ mA		15	50	mV
	1 mA $\leq I_R \leq 10$ mA		50	150	mV
Reverse Dynamic Impedance (Note 3)	$I_R = 3$ mA		5	25	Ω
	$I_R = 0.3$ mA		15	60	Ω
Reverse Leakage Current	$V_R = V_Z - 0.2V$		2	5	μA
Forward Voltage Drop	$I_F = 10$ mA	0.7	0.8	1.0	V
Peak-to-Peak Broadband Noise Voltage	10 Hz $\leq f \leq 100$ kHz, $I_R = 1$ mA		300		μV
Reverse Breakdown Voltage Change (Note 4)	$10\ \mu A \leq I_R \leq 100\ \mu A$			200	mV
	$100\ \mu A \leq I_R \leq 1$ mA			60	mV
	1 mA $\leq I_R \leq 10$ mA			200	mV
Breakdown Voltage Temperature Coefficient (Note 4)	$100\ \mu A \leq I_R \leq 1$ mA		-5.0		mV/°C

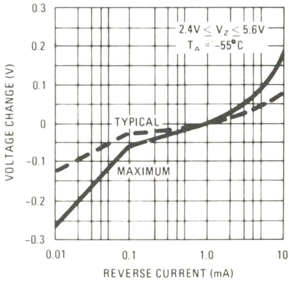
NOTE 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 80°C/W junction to case or 440°C/W junction to ambient (see curve).

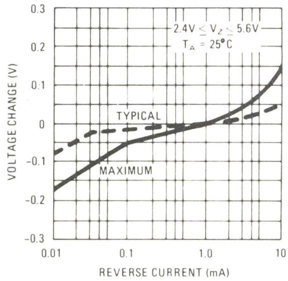
NOTE 2: These specifications apply for $T_A = 25^\circ$C and $1.8V < V_Z < 5.6V$ unless stated otherwise. The diode should not be operated with shunt capacitances between 100 pF and 0.01 μF, unless isolated by at least a 50Ω resistor, as it may oscillate at some currents.

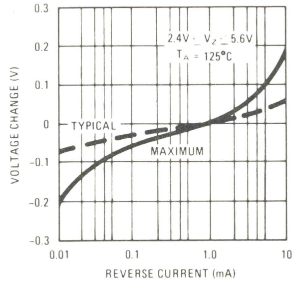
NOTE 3: Measured with the peak-to-peak change of reverse current equal to 10 percent of the dc reverse current.

NOTE 4: These specifications apply for $-55^\circ C < T_A < 125^\circ C$.

guaranteed reverse characteristics

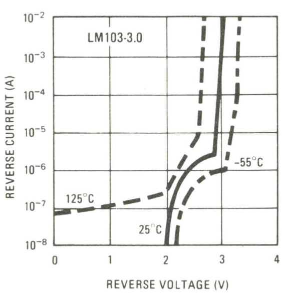




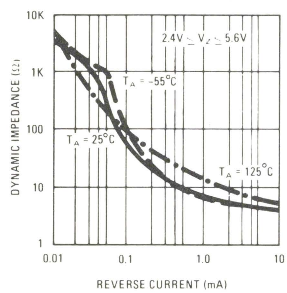


typical performance characteristics

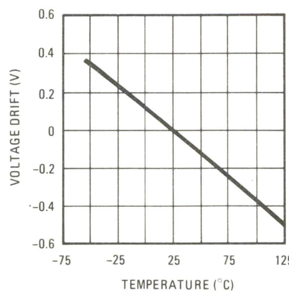
Reverse Characteristics



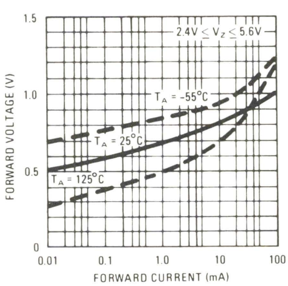
Reverse Dynamic Impedance



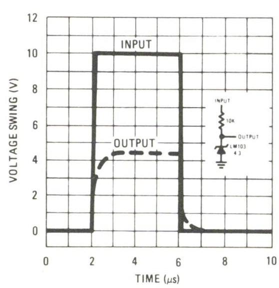
Temperature Drift



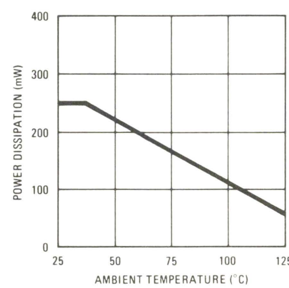
Forward Characteristics



Response Time



Maximum Power Dissipation



BREAKDOWN VOLTAGE*	PART NUMBER
1.8	LM103-1.8
2.0	LM103-2.0
2.2	LM103-2.2
2.4	LM103-2.4
2.7	LM103-2.7
3.0	LM103-3.0
3.3	LM103-3.3
3.6	LM103-3.6
3.9	LM103-3.9
4.3	LM103-4.3
4.7	LM103-4.7
5.1	LM103-5.1
5.6	LM103-5.6

*Measured at I_R = 1 mA.
Standard tolerance is ±10%.

Voltage Regulators

LM104/LM204 negative regulator general description

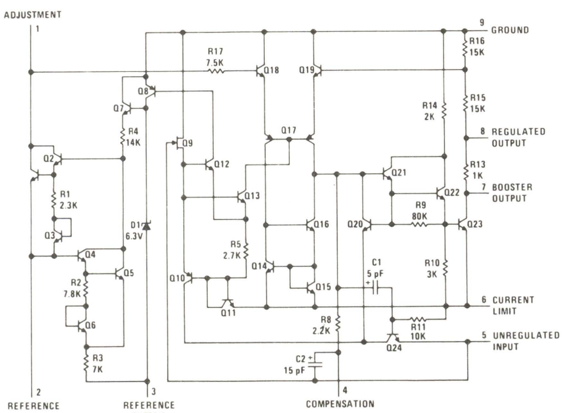
The LM104 and LM204 are precision voltage regulators which can be programmed by a single external resistor to supply any voltage from 40V down to zero while operating from a single unregulated supply. They can also provide 0.01-percent regulation in circuits using a separate, floating bias supply, where the output voltage is limited only by the breakdown of external pass transistors. Although designed primarily as linear, series regulators, the circuits can be used as switching regulators, current regulators or in a number of other control applications. Typical performance characteristics are:

- 1 mV regulation no load to full load
- 0.01%/V line regulation
- 0.2 mV/V ripple rejection
- 0.3% temperature stability over military temperature range

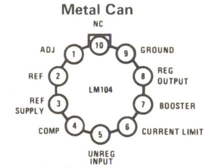
The LM104 and LM204 are complements of the LM100 and LM105 positive regulators, intended for systems requiring regulated negative voltages which have a common ground with the unregulated supply. By themselves, they can deliver output currents to 25 mA, but external transistors can be added to get any desired current. The output voltage is set by external resistors, and either constant or foldback current limiting is made available.

The LM104 is specified for operation over the −55°C to +125°C military temperature range. The LM204 is specified for operation over the −25°C to +85°C temperature range.

schematic and connection diagrams



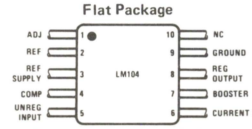
Metal Can



Note: Pin 5 connected to case.
TOP VIEW

Order Number LM104H or LM204H
See Package 12

Flat Package

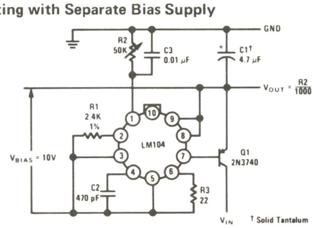


Note: Pin 5 connected to bottom of package.
TOP VIEW

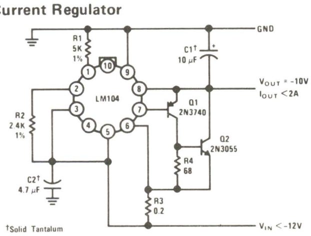
Order Number LM104F or LM204F
See Package 3

typical applications

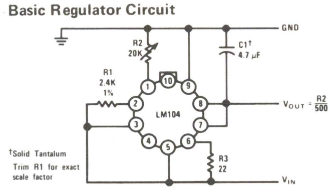
Operating with Separate Bias Supply



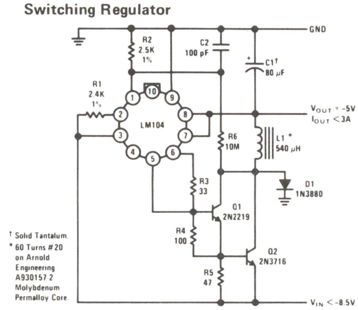
High Current Regulator



Basic Regulator Circuit



Switching Regulator



absolute maximum ratings

Input Voltage	50V
Input-Output Voltage Differential	50V
Power Dissipation (Note 1)	500 mW
Operating Temperature Range	
LM104	−55°C to 125°C
LM204	−25°C to 85°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		−50		−8	V
Output Voltage Range		−40		−0.015	V
Output-Input Voltage Differential (Note 3)	I_O = 20 mA	2.0		50	V
	I_O = 5 mA	0.5		50	V
Load Regulation (Note 4)	$0 \leq I_O \leq 20$ mA, $R_{SC} = 15\Omega$		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leq -5V$, $\Delta V_{IN} = 0.1\ V_{IN}$		0.056	0.1	%
Ripple Rejection	$C_{19} = 10\ \mu F$, f = 120 Hz				
	$V_{IN} < -15V$		0.2	0.5	mV/V
	$-7V \geq V_{IN} \geq -15V$		0.5	1.0	mV/V
Output Voltage Scale Factor	R_{23} = 2.4k	1.8	2.0	2.2	V/kΩ
Temperature Stability	$V_O \leq -1V$		0.3	1.0	%
Output Noise Voltage	$10\ Hz \leq f \leq 10\ kHz$				
	$V_O \leq -5V$, $C_{19} = 0$		0.007		%
	$C_{19} = 10\ \mu F$		15		μV
Standby Current Drain	I_L = 5 mA, V_O = 0		1.7	2.5	mA
	$V_O = -40V$		3.6	5.0	mA
Long Term Stability	$V_O \leq -1V$		0.1	1.0	%

Note 1: The maximum junction temperature of the LM104 is 150°C, while that of the LM204 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.

Note 2: These specifications apply for junction temperatures between −55°C and 150°C (between −25°C and 100°C for the LM204) and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

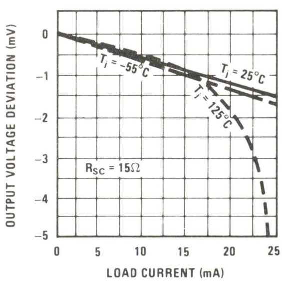
Note 3: When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

Note 4: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

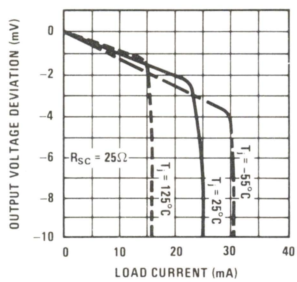
Note 5: With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and −5V, a dc output variation, determined from the ripple rejection, must be added to find the worst-case line regulation.

typical performance characteristics

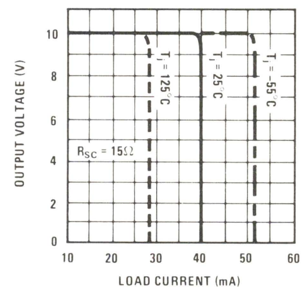
Load Regulation



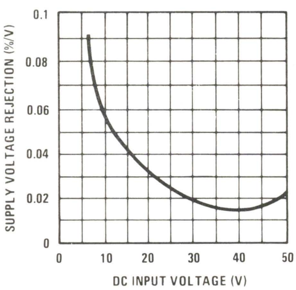
Load Regulation



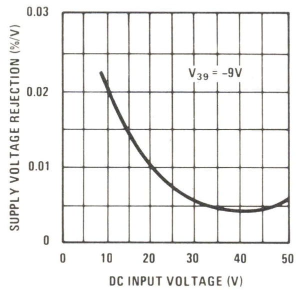
Current Limiting



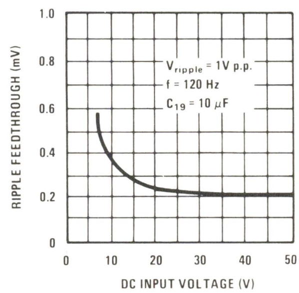
Supply Voltage Rejection



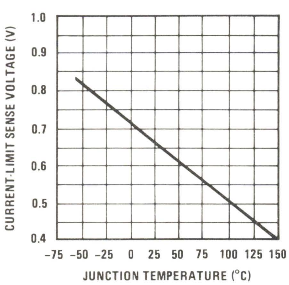
Supply Voltage Rejection With Preregulated Reference Supply



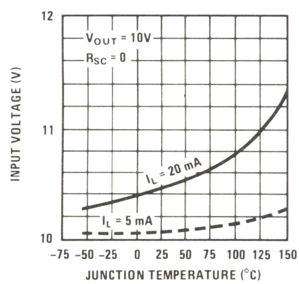
Ripple Rejection



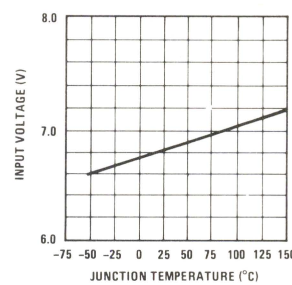
Current Limit Sense Voltage



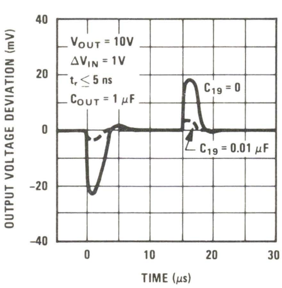
Regulator Dropout Voltage



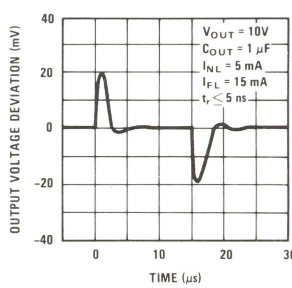
Minimum Input Voltage



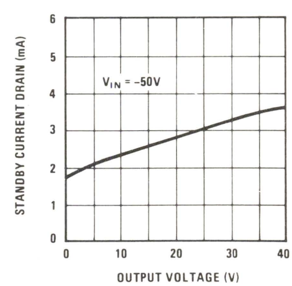
Line Transient Response



Load Transient Response



Standby Current Drain



1

Voltage Regulators

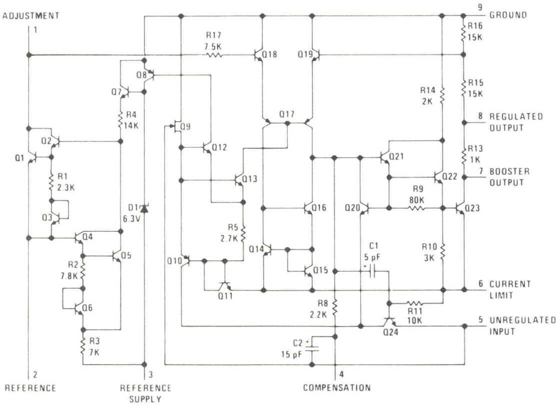
LM304 negative regulator general description

The LM304 is a precision voltage regulator which can be programmed by a single external resistor to supply any voltage from 30V down to zero while operating from a single unregulated supply. It can also provide 0.01-percent regulation in circuits using a separate, floating bias supply, where the output voltage is limited only by the breakdown of external pass transistors. Although designed primarily as a linear, series regulator, the circuit can be used as a switching regulator, a current regulator or in a number of other control applications. Typical performance characteristics are:

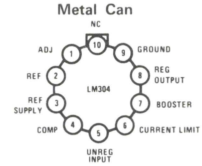
- 1 mV regulation no load to full load
- 0.01%/V line regulation
- 0.2 mV/V ripple rejection

The LM304 is a complement of the LM300 and LM305 positive regulators, intended for systems requiring regulated negative voltages which have a common ground with the unregulated supply. By itself, it can deliver output currents to 25 mA, but external transistors can be added to get any desired current. The output voltage is set by external resistors, and either constant or foldback current limiting is made available. The LM304 is a commercial/industrial version of the LM104 and LM204.

schematic and connection diagrams



Metal Can



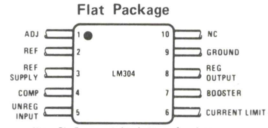
Note: Pin 5 connected to case.

TOP VIEW

Order Number LM304H

See Package 12

Flat Package



Note: Pin 5 connected to bottom of package.

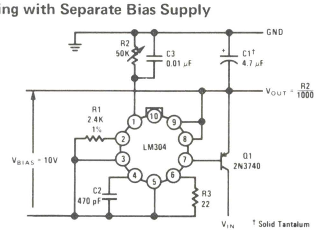
TOP VIEW

Order Number LM304F

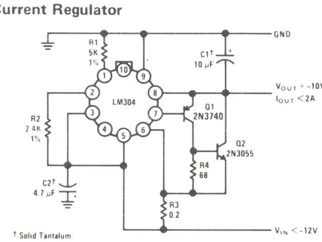
See Package 3

typical applications

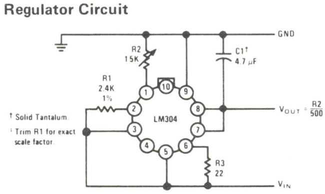
Operating with Separate Bias Supply



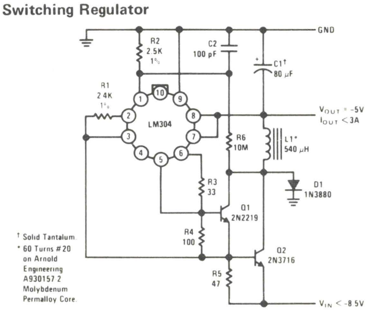
High Current Regulator



Basic Regulator Circuit



Switching Regulator



absolute maximum ratings

Input Voltage	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	500 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		−40		−8	V
Output Voltage Range		−30		−0.035	V
Output-Input Voltage Differential (Note 3)	$I_O = 20$ mA	2.0		40	V
	$I_O = 5$ mA	0.5		40	V
Load Regulation (Note 4)	$0 \leq I_O \leq 20$ mA $R_{SC} = 15\Omega$		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leq -5V$ $\Delta V_{IN} = 0.1\ V_{IN}$		0.056	0.1	%
Ripple Rejection	$C_{19} = 10\ \mu F$, f = 120 Hz				
	$V_{IN} < -15V$		0.2	0.5	mV/V
	$-7V \geq V_{IN} \geq -15V$		0.5	1.0	mV/V
Output Voltage Scale Factor	$R_{23} = 2.4K$	1.8	2.0	2.2	V/KΩ
Temperature Stability	$V_O \leq -1V, 0°C \leq T_A \leq 70°C$		0.3	1.0	%
Output Noise Voltage	$10\ Hz \leq f \leq 10\ KHz$				
	$V_O \leq -5V, C_{19} = 0$		0.007		%
	$C_{19} = 10\ \mu F$		15		μV
Standby Current Drain	$I_L = 5$ mA, $V_O = 0$		1.7	2.5	mA
	$V_O = -30V$		3.6	5.0	mA
Long Term Stability	$V_O \leq -1V$		0.1	1.0	%

Note 1: For operating at elevated temperatures, the device must be derated based on an 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient. Peak dissipations to 1.0W are allowable providing the dissipation rating is not exceeded with the power averaged over a two second interval.

Note 2: These specifications apply for junction temperatures between 0°C and 85°C and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

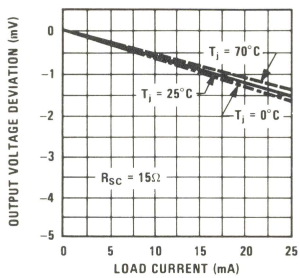
Note 3: When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

Note 4: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

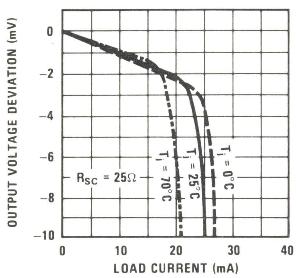
Note 5: With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and −5V, a dc output variation, determined from the ripple rejection, must be added to find the worst-case line regulation.

typical performance characteristics

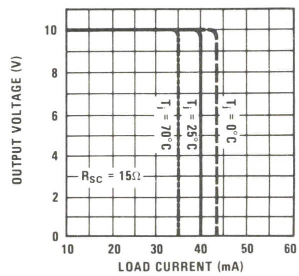
Load Regulation



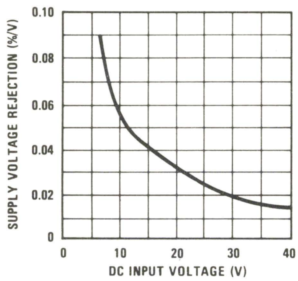
Load Regulation



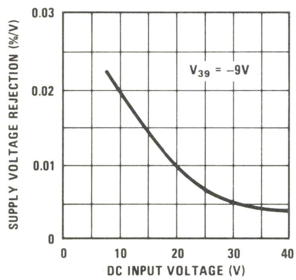
Current Limiting



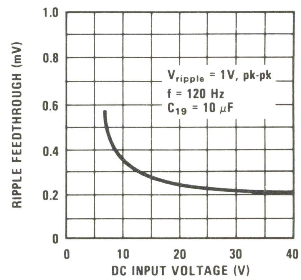
Supply Voltage Rejection



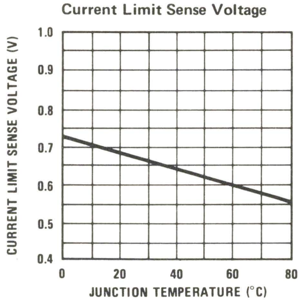
Supply Voltage Rejection With Preregulated Reference Supply



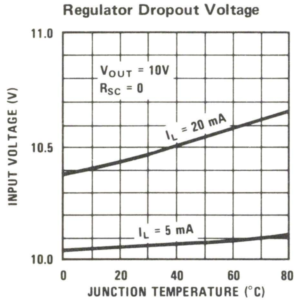
Ripple Rejection



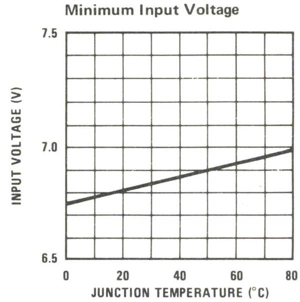
Current Limit Sense Voltage



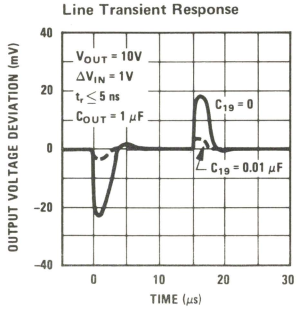
Regulator Dropout Voltage



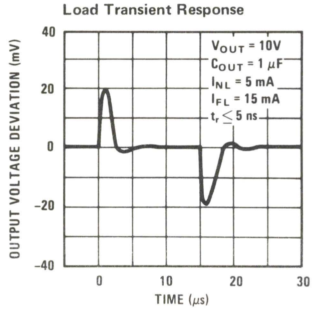
Minimum Input Voltage



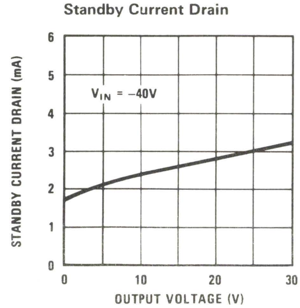
Line Transient Response



Load Transient Response



Standby Current Drain



Voltage Regulators

LM105/LM205/LM305 voltage regulator

general description

The LM105, LM205 and LM305 are positive voltage regulators similar to the LM100, except that an extra gain stage has been added for improved regulation. A redesign of the biasing circuitry removes any minimum load current requirement and at the same time reduces standby current drain, permitting higher voltage operation. They are direct, plug-in replacements for the LM100 in both linear and switching regulator circuits with output voltages greater than 4.5V. Important characteristics of the circuits are:

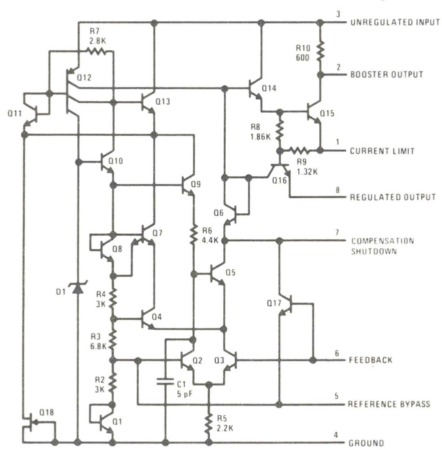
- Output voltage adjustable from 4.5V to 40V
- Output currents in excess of 10A possible by adding external transistors
- Load regulation better than 0.1%, full load with current limiting
- DC line regulation guaranteed at 0.03%/V
- Ripple rejection of 0.01%/V

Like the LM100, they also feature fast response to both load and line transients, freedom from oscillations with varying resistive and reactive loads and the ability to start reliably on any load within rating. The circuits are built on a single silicon chip and are supplied in either an 8-lead, TO-5 header or a 1/4" x 1/4" metal flat package.

The LM205 is identical to the LM105 except that it is specified for operation from −25°C to 85°C.

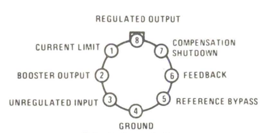
The LM305 is specified for operation from 0°C to 70°C and for output voltages to 30V.

schematic and connection diagrams



Pin connections shown are for metal can.

Metal Can

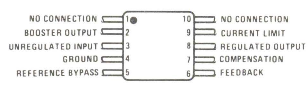


Note: Pin 4 connected to case

TOP VIEW

Order Number LM105H or LM205H or LM305H
See Package 11

Flat Package

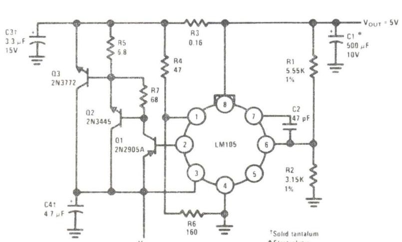


Note: Pin 4 connected to bottom of package

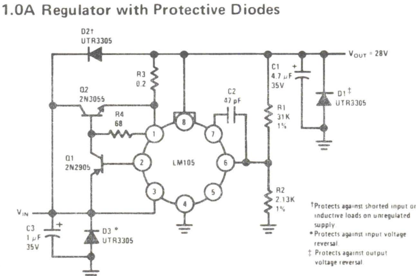
Order Number LM105F or LM205F or LM305F
See Package 3

typical applications

10A Regulator with Foldback Current Limiting



1.0A Regulator with Protective Diodes



absolute maximum ratings

Input Voltage	
LM105, LM205	50V
LM305	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	
LM105, LM205	800 mW
LM305	500 mW
Operating Temperature Range	0°C to 70°C
LM105	–55°C to +125°C
LM205	–25°C to +85°C
LM305	0°C to 70°C
Storage Temperature Range	–65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range					
LM105, LM205		8.5		50	V
LM305		8.5		40	V
Output Voltage Range					
LM105, LM205		4.5		40	V
LM305		4.5		30	V
Output-Input Voltage Differential		3.0		30	V
Load Regulation (Note 3)					
LM105	$0 \leq I_O \leq 12$ mA				
	$R_{SC} = 10\Omega$, $T_A = 25°C$		0.02	0.05	%
	$R_{SC} = 10\Omega$, $T_A = 125°C$		0.03	0.1	%
	$R_{SC} = 10\Omega$, $T_A = -55°C$		0.03	0.1	%
LM205	$0 \leq I_o \leq 12$ mA				
	$R_{SC} = 10\Omega$, $T_A = 25°C$		0.02	0.05	%
	$R_{SC} = 10\Omega$, $T_A = 85°C$		0.03	0.1	%
	$R_{SC} = 10\Omega$, $T_A = -25°C$		0.03	0.1	%
LM305	$0 \leq I_O \leq 12$ mA				
	$R_{SC} = 10\Omega$, $T_A = 25°C$		0.02	0.05	%
	$R_{SC} = 15\Omega$, $T_A = 70°C$		0.03	0.1	%
	$R_{SC} = 10\Omega$, $T_A = 0°C$		0.03	0.1	%
Line Regulation	$V_{IN} - V_{OUT} \leq 5V$		0.025	0.06	%/V
	$V_{IN} - V_{OUT} > 5V$		0.015	0.03	%/V
Ripple Rejection	$C_{REF} = 10\ \mu F$, f = 120 Hz		0.003	0.01	%/V
Temperature Stability					
LM105	$-55°C \leq T_A \leq 125°C$		0.3	1.0	%
LM205	$-25°C \leq T_A \leq 85°C$		0.3	1.0	%
LM305	$0°C \leq T_A \leq 70°C$		0.3	1.0	%
Feedback Sense Voltage		1.63	1.7	1.81	V
Output Noise Voltage	10 Hz $\leq f \leq$ 10 kHz				
	$C_{REF} = 0$		0.005		%
	$C_{REF} > 0.1\ \mu F$		0.002		%
Current Limit Sense Voltage	$R_{SC} = 10\Omega$, $T_A = 25°C$, $V_{OUT} = 0V$	225	300	315	mV
Standby Current Drain					
LM105, LM205	$V_{IN} = 50V$		0.8	2.0	mA
LM305	$V_{IN} = 40V$		0.8	2.0	mA
Long Term Stability			0.1	1.0	%

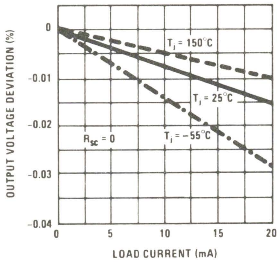
Note 1: The maximum junction temperature of the LM105 is 150°C, while that for the LM205 is 100°C, and that for the LM305 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. Peak dissipations to 1W are allowable providing the dissipation rating is not exceeded with the power averaged over a five second interval for the LM105 and LM205, and averaged over a two second interval for the LM305.

Note 2: These specifications apply for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 kΩ, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation. Unless otherwise specified, $T_A = 25°C$.

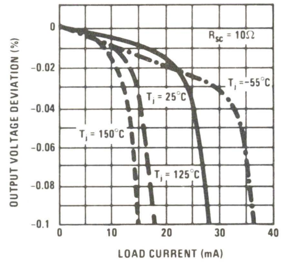
Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

typical performance characteristics

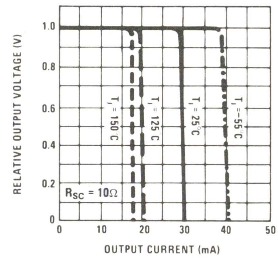
Load Regulation



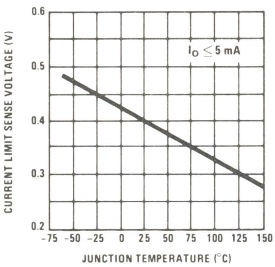
Load Regulation



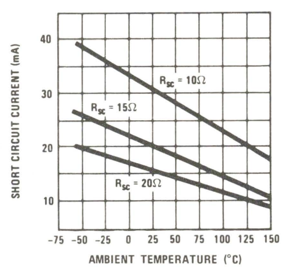
Current Limiting Characteristics



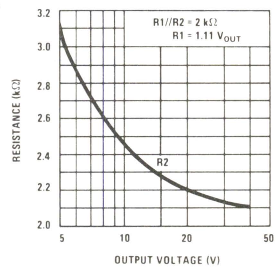
Current Limit Sense Voltage



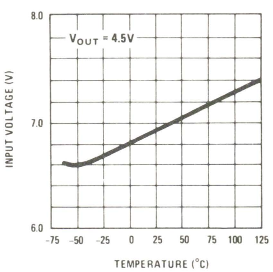
Short Circuit Current



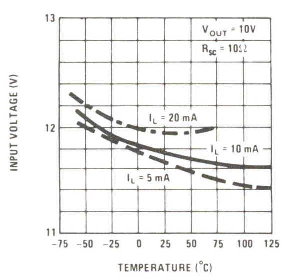
Optimum Divider Resistance Values



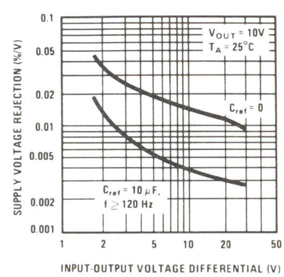
Minimum Input Voltage



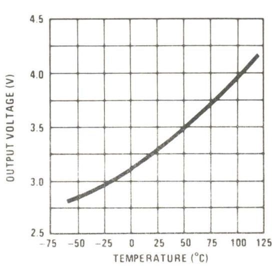
Regulator Dropout Voltage



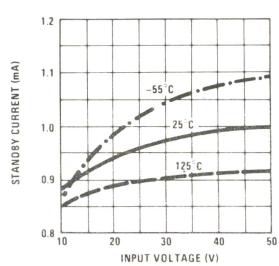
Supply Voltage Rejection



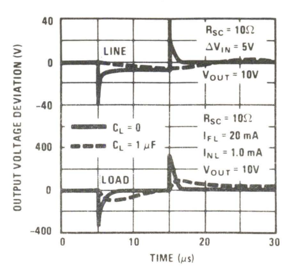
Minimum Output Voltage



Standby Current Drain



Transient Response



1

Voltage Regulators

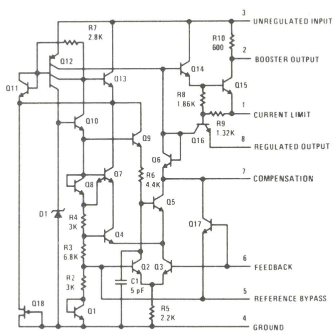
LM305A voltage regulator general description

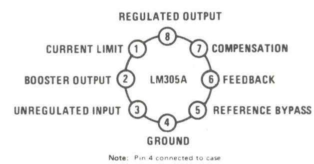
The LM305A is a positive voltage regulator designed primarily for commercial series regulator applications. By itself, it will supply output currents up to 45 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics are:

- 45 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Maximum input voltage = 50V
- Output voltage adjustable from 4.5V to 40V
- Can be used as either a linear or a switching regulator

The LM305A is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

schematic and connection diagrams

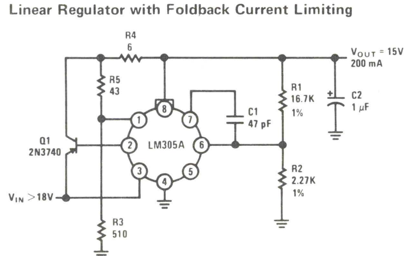




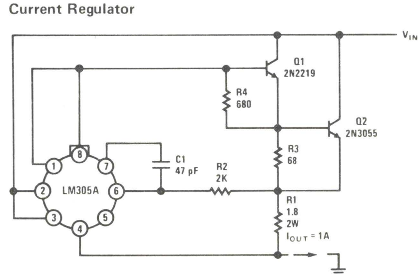
Order Number LM305AH
See Package 11

typical applications

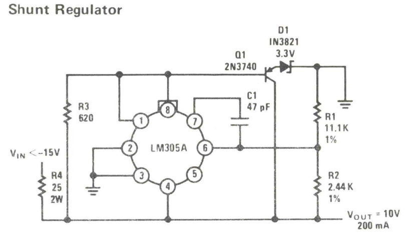
Linear Regulator with Foldback Current Limiting



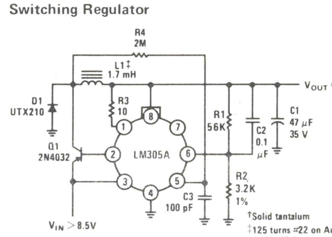
Current Regulator



Shunt Regulator



Switching Regulator



†Solid tantalum
‡125 turns #22 on Arnold Engineering A262123-2 molybdenum permalloy core.

absolute maximum ratings

Input Voltage	50V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 60 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		8.5		50	V
Output Voltage Range		4.5		40	V
Output-Input Voltage Differential		3.0		30	V
Load Regulation (Note 3)	$0 \leq I_O \leq 45$ mA				
	$R_{SC} = 0\Omega$, $T_A = 25°C$		0.02	0.2	%
	$R_{SC} = 0\Omega$, $T_A = 70°C$		0.03	0.4	%
	$R_{SC} = 0\Omega$, $T_A = 0°C$		0.03	0.4	%
Line Regulation	$V_{IN} - V_{OUT} \leq 5V$		0.025	0.06	%/V
	$V_{IN} - V_{OUT} > 5V$		0.015	0.03	%/V
Ripple Rejection	$C_{REF} = 10\ \mu F$, f = 120 Hz		0.003		%/V
Temperature Stability	$0°C \leq T_A \leq 70°C$		0.3	1.0	%
Feedback Sense Voltage		1.55	1.7	1.85	V
Output Noise Voltage	$10\ Hz \leq f \leq 10\ kHz$				
	$C_{REF} = 0$		0.005		%
	$C_{REF} > 0.1\ \mu F$		0.002		%
Current Limit Sense Voltage (Note 4)	$R_{SC} = 10\Omega$, $T_A = 25°C$, $V_{OUT} = 0V$	225	300	375	mV
Standby Current Drain	$V_{IN} = 50V$		0.8	2.0	mA
Long Term Stability			0.1	1.0	%

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient.

Note 2: These specifications apply for an operating temperature between 0°C and 70°C, for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 KΩ, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

Note 4: With no external pass transistor.

Voltage Regulators

LM109/LM209 five-volt regulator

general description

The LM109 and LM209 are complete 5V regulators fabricated on a single silicon chip. They are designed for local regulation on digital logic cards, eliminating the distribution problems associated with single-point regulation. The devices are available in two common transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulators are essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

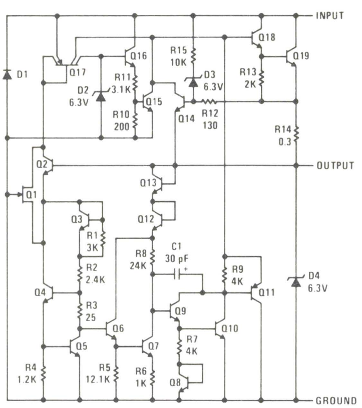
Considerable effort was expended to make these devices easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM109 and LM209 can be set to voltages above 5V, as shown below. It is also possible to use the circuits as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

To summarize, outstanding features of the regulator are:

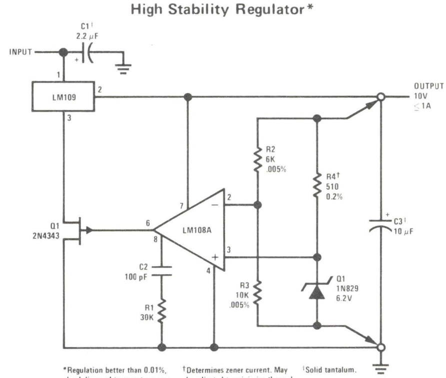
- Specified to be complete, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

schematic diagram



typical application

High Stability Regulator*



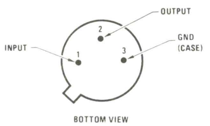
*Regulation better than 0.01%, load, line and temperature, can be obtained.

†Determines zener current. May be adjusted to minimize thermal drift.

‡Solid tantalum.

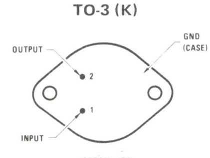
connection diagrams

TO-5 (H)



Order Number LM109H or LM209H
See Package 9

TO-3 (K)



Order Number LM109K or LM209K
See Package 18

absolute maximum ratings

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	−55°C to 150°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

design characteristics (Note 1)

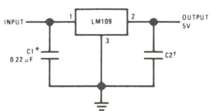
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25°C$	4.7	5.05	5.3	V
Line Regulation	$T_j = 25°C$ $7V \leq V_{IN} \leq 25V$		4	50	mV
Load Regulation	$T_j = 25°C$				
LM109H	$5\ mA \leq I_{OUT} \leq 0.5A$		20	50	mV
LM109K	$5\ mA \leq I_{OUT} \leq 1.5A$		50	100	mV
Output Voltage	$7V \leq V_{IN} \leq 25V$ $5\ mA \leq I_{OUT} \leq I_{max}$ $P < P_{max}$	4.6		5.4	V
Quiescent Current	$7V \leq V_{IN} \leq 25V$		5.2	10	mA
Quiescent Current Change	$7V \leq V_{IN} \leq 25V$ $5\ mA \leq I_{OUT} \leq I_{max}$			0.5 0.8	mA mA
Output Noise Voltage	$T_A = 25°C$ $10\ Hz \leq f \leq 100\ kHz$		40		μV
Long Term Stability				10	mV
Thermal Resistance Junction to Case (Note 2)					
LM109H			15		°C/W
LM109K			3		°C/W

Note 1: Unless otherwise specified, these specifications apply for $-55°C \leq T_j \leq 150°C$ ($-25°C \leq T_j \leq 150°C$ for the LM209), $V_{IN} = 10V$ and $I_{OUT} = 0.1A$ for the TO-5 package or $I_{OUT} = 0.5A$ for the TO-3 package. For the TO-5 package, $I_{max} = 0.2A$ and $P_{max} = 2.0W$. For the TO-3 package, $I_{max} = 1.0A$ and $P_{max} = 20W$.

Note 2: Without a heat sink, the thermal resistance of the TO-5 package is about 150°C/W, while that of the TO-3 package is approximately 35°C/W. With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

typical applications(con't)

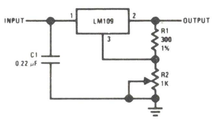
Fixed 5V Regulator



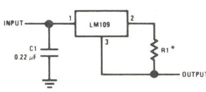
*Required if regulator is located an appreciable distance from power supply filter.

†Although no output capacitor is needed for stability, it does improve transient response.

Adjustable Output Regulator



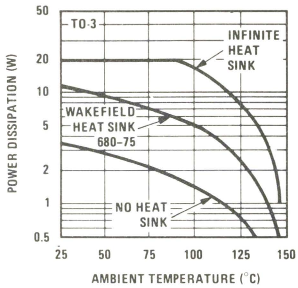
Current Regulator



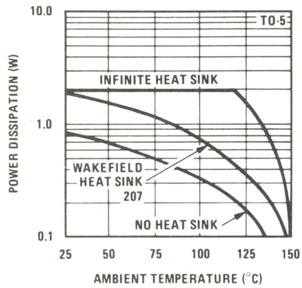
*Determines output current

typical performance characteristics

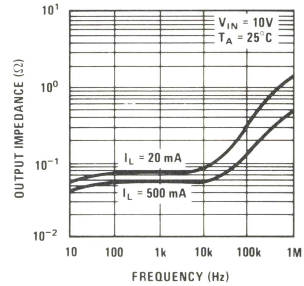
Maximum Average Power Dissipation



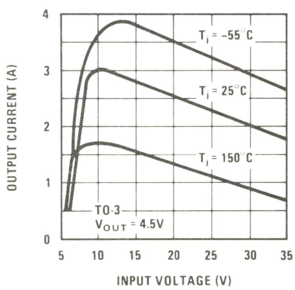
Maximum Average Power Dissipation



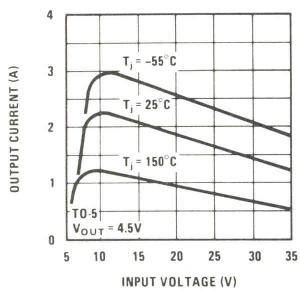
Output Impedance



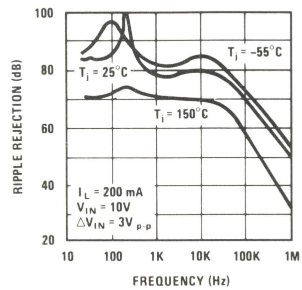
Peak Output Current



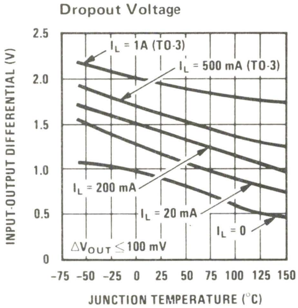
Peak Output Current



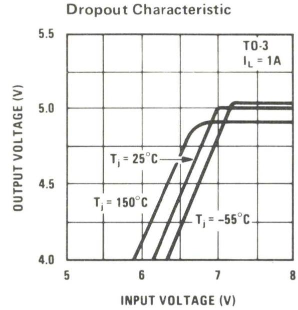
Ripple Rejection



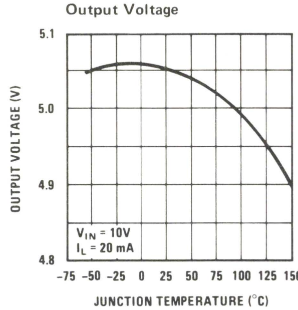
Dropout Voltage



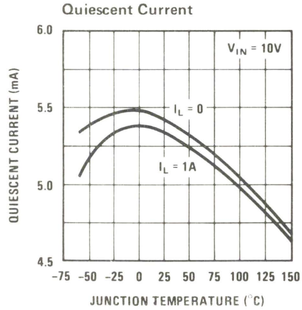
Dropout Characteristic



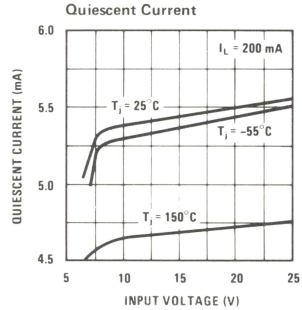
Output Voltage



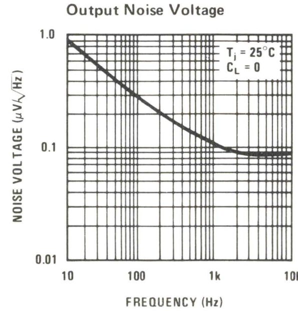
Quiescent Current



Quiescent Current



Output Noise Voltage



Voltage Regulators

LM309 five-volt regulator

general description

The LM309 is a complete 5V regulator fabricated on a single silicon chip. It is designed for local regulation on digital logic cards, eliminating the distribution problems associated with single-point regulation. The device is available in two common transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulator is essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

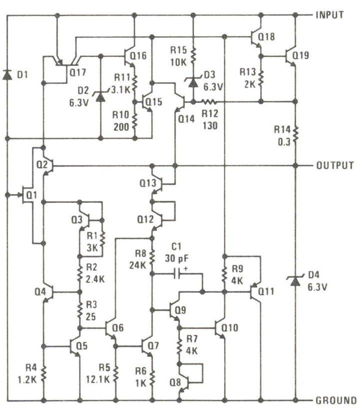
Considerable effort was expended to make the LM309 easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM309 can be set to voltages above 5V, as shown below. It is also possible to use the circuit as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

To summarize, outstanding features of the regulator are:

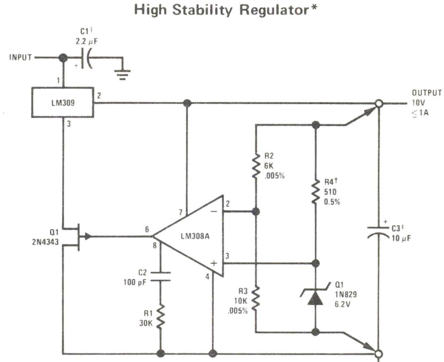
- Specified to be compatible, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

schematic diagram



typical application

High Stability Regulator*



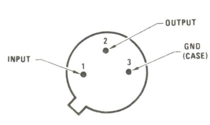
*Regulation better than 0.01%, load, line and temperature, can be obtained.

†Determines zener current. May be adjusted to minimize thermal drift.

‡Solid tantalum.

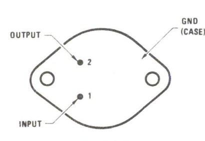
connection diagrams

TO-5 (H)



Order Number LM309H
See Package 9

TO-3 (K)



Order Number LM309K
See Package 18

absolute maximum ratings

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	0°C to 125°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

design characteristics (Note 1)

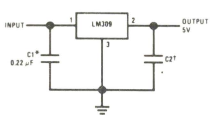
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25°C$	4.8	5.05	5.2	V
Line Regulation	$T_j = 25°C$ $7V \leq V_{IN} \leq 25V$		4.0	50	mV
Load Regulation	$T_j = 25°C$				
LM309H	$5\ mA \leq I_{OUT} \leq 0.5A$		20	50	mV
LM309K	$5\ mA \leq I_{OUT} \leq 1.5A$		50	100	mV
Output Voltage	$7V \leq V_{IN} \leq 25V$ $5\ mA \leq I_{OUT} \leq I_{max}$ $P < P_{max}$	4.75		5.25	V
Quiescent Current	$7V \leq V_{IN} \leq 25V$		5.2	10	mA
Quiescent Current Change	$7V \leq V_{IN} \leq 25V$ $5\ mA \leq I_{OUT} \leq I_{max}$			0.5 0.8	mA mA
Output Noise Voltage	$T_A = 25°C$ $10\ Hz \leq f \leq 100\ kHz$		40		μV
Long Term Stability				20	mV
Thermal Resistance Junction to Case (Note 2)					
LM309H			15		°C/W
LM309K			3.0		°C/W

Note 1: Unless otherwise specified, these specifications apply for $0°C \leq T_j \leq 125°C$, $V_{IN} = 10V$ and $I_{OUT} = 0.1A$ for the LM309H or $I_{OUT} = 0.5A$ for the LM309K. For the LM309H, $I_{max} = 0.2A$ and $P_{max} = 2.0W$. For the LM309K, $I_{max} = 1.0A$ and $P_{max} = 20W$.

Note 2: Without a heat sink, the thermal resistance of the TO-5 package is about 150°C/W, while that of the TO-3 package is approximately 35°C/W. With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

typical applications(con't)

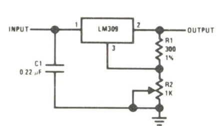
Fixed 5V Regulator



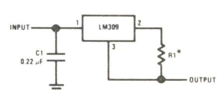
*Required if regulator is located an appreciable distance from power supply filter.

†Although no output capacitor is needed for stability, it does improve transient response.

Adjustable Output Regulator



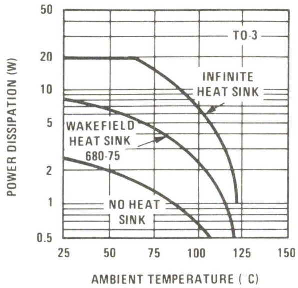
Current Regulator



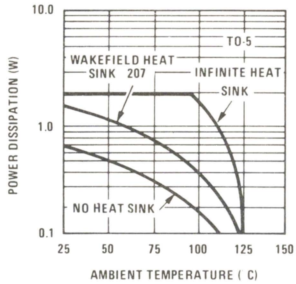
*Determines output current

typical performance characteristics

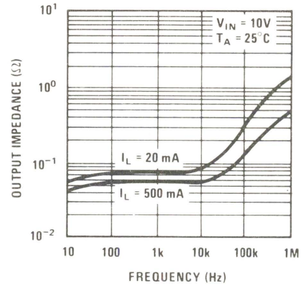
Maximum Average Power Dissipation



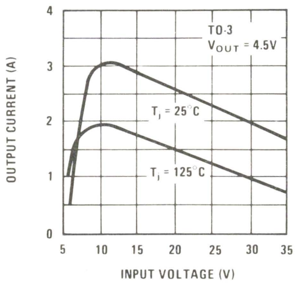
Maximum Average Power Dissipation



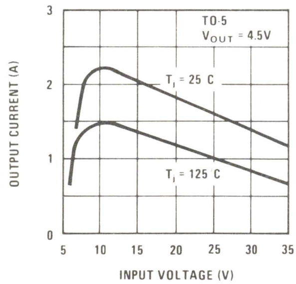
Output Impedance



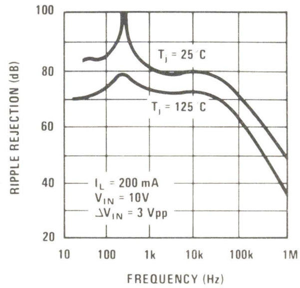
Peak Output Current



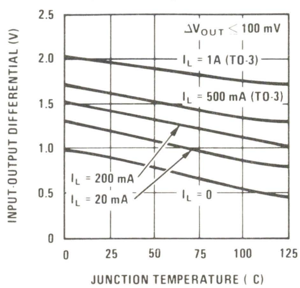
Peak Output Current



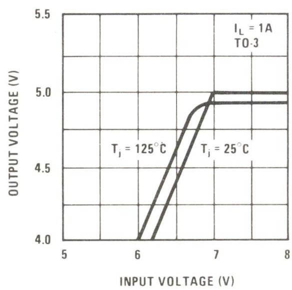
Ripple Rejection



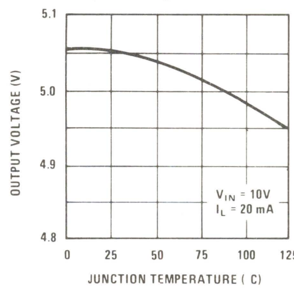
Dropout Voltage



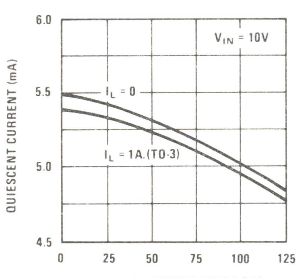
Dropout Characteristic



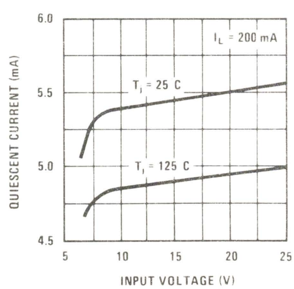
Output Voltage



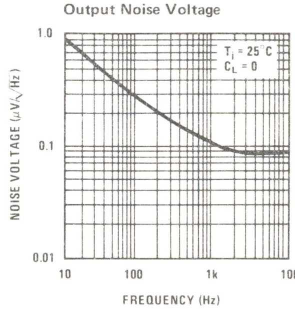
Quiescent Current



Quiescent Current



Output Noise Voltage



Voltage Regulators

LM113 reference diode

general description

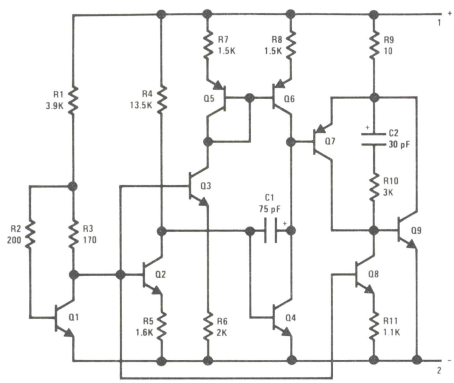
The LM113 is a temperature-compensated, low-voltage reference diode. It features extremely-tight regulation over a wide range of operating currents in addition to an unusually-low breakdown voltage and good temperature stability.

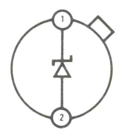
The diode is synthesized using transistors and resistors in a monolithic integrated circuit. As such, it has the same low noise and long term stability as modern IC op amps. Further, output voltage of the reference depends only on highly-predictable properties of components in the IC; so it can be manufactured and supplied to tight tolerances. Outstanding features include:

- Low breakdown voltage: 1.220V
- Dynamic impedance of 0.3Ω from 500 μA to 20 mA
- Temperature stability typically 1% over −55°C to 125°C range
- Tight tolerance: ±5% standard, ±2% and ±1% on special order.

The characteristics of this reference recommend it for use in bias-regulation circuitry, in low-voltage power supplies or in battery powered equipment. The fact that the breakdown voltage is equal to a physical property of silicon—the energy-band-gap voltage—makes it useful for many temperature-compensation and temperature-measurement functions.

schematic and connection diagrams



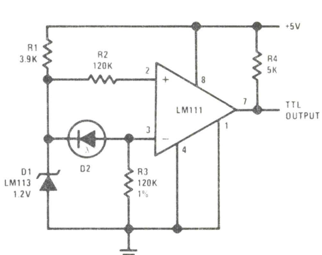


NOTE: Pin 2 connected to case.
TOP VIEW

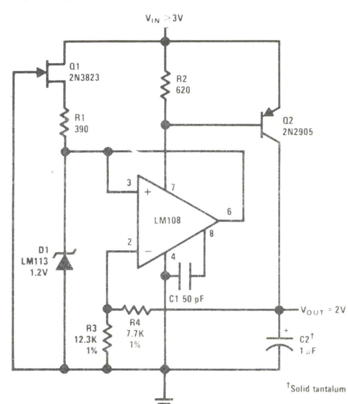
Order Number LM113H
See Package 8

typical applications

Level Detector for Photodiode



Low Voltage Regulator



absolute maximum ratings

Power Dissipation (Note 1)	100 mW
Reverse Current	50 mA
Forward Current	50 mA
Operating Temperature Range	−55°C to 125°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

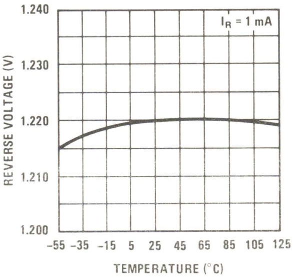
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	I_R = 1 mA	1.160	1.220	1.280	V
Reverse Breakdown Voltage Change	0.5 mA $\leq I_R \leq$ 20 mA		6.0	15	mV
Reverse Dynamic Impedance	I_R = 1 mA I_R = 10 mA		0.2 0.25	1.0 0.8	Ω Ω
Forward Voltage Drop	I_F = 1.0 mA		0.67	1.0	V
RMS Noise Voltage	10 Hz $\leq f \leq$ 10 kHz I_R = 1 mA		5		μV
Reverse Breakdown Voltage Change	0.5 mA $\leq I_R \leq$ 10 mA −55°C $\leq T_A \leq$ 125°C			15	mV
Breakdown Voltage Temperature Coefficient	1.0 mA $\leq I_R \leq$ 10 mA −55°C $\leq T_A \leq$ 125°C		0.01		%/°C

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction and a thermal resistance of 80°C/W junction to case or 440°C/W junction to ambient.

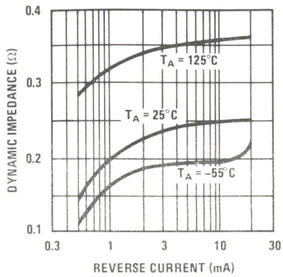
Note 2: These specifications apply for T_A = 25°C, unless stated otherwise. At high currents, breakdown voltage should be measured with lead lengths less than 1/4 inch. Kelvin contact sockets are also recommended. The diode should not be operated with shunt capacitances between 200 pF and 0.1 μF, unless isolated by at least a 100 Ω resistor, as it may oscillate at some currents.

typical performance characteristics

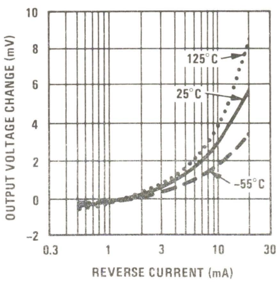
Temperature Drift



Reverse Dynamic Impedance

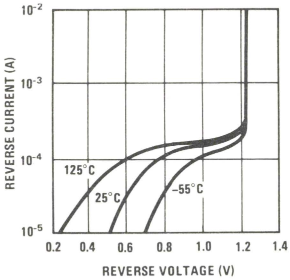


Reverse Characteristics

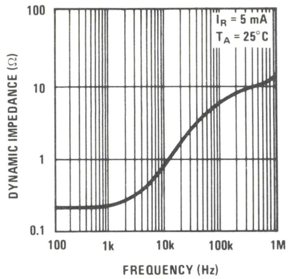


typical performance characteristics (con't)

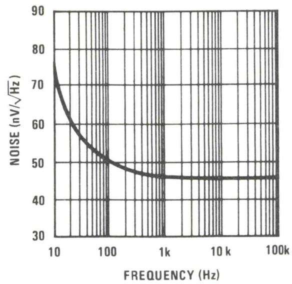
Reverse Characteristics



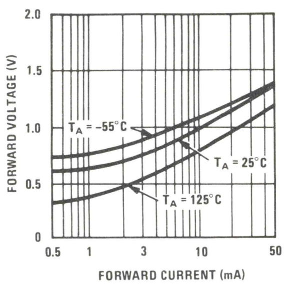
Reverse Dynamic Impedance



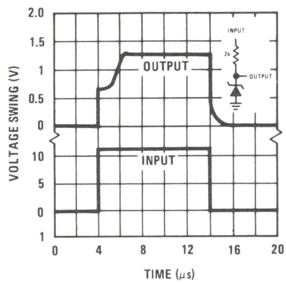
Noise Voltage



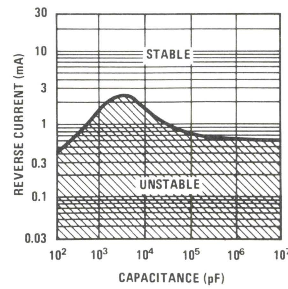
Forward Characteristics



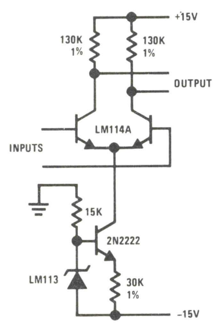
Response Time



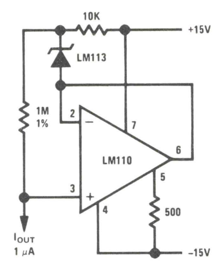
Maximum Shunt Capacitance



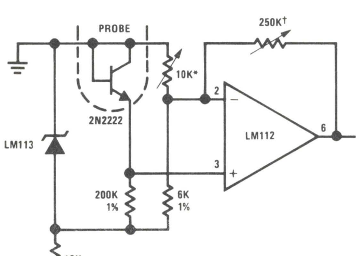
typical applications (con't)



Amplifier Biasing for Constant Gain with Temperature



Constant Current Source



*Adjust for 0V at 0°C
†Adjust for 100 mV/°C

Thermometer

Voltage Regulators

LM120 series three-terminal negative regulators

general description

The LM120 Series are three-terminal negative regulators with a fixed output voltage of −5V, −5.2V, −12V, and −15V and up to 1.5A load current capability. These devices need only one external component — a compensation capacitor at the output, making them easy to apply. Worst case guarantees on output voltage deviation due to any combination of line, load or temperature variation assure satisfactory system operation.

Exceptional effort has been made to make the LM120 Series immune to overload conditions. The regulators have current limiting which is independent of temperature, combined with thermal overload protection. Internal current limiting protects against momentary faults while thermal shutdown prevents junction temperatures from exceeding safe limits during prolonged overloads.

Although primarily intended for fixed output voltage applications, the LM120 Series may be programmed for higher output voltages with a simple resistive divider. The low quiescent drain current of the devices allows this technique to be used with good regulation.

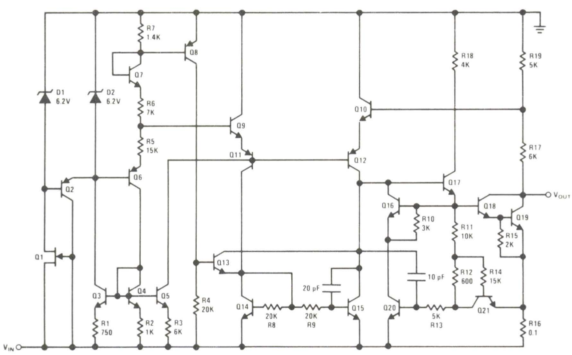
The LM120 Series is available in TO-5 and TO-3 packages. The TO-5 is rated at 200 mA and 2W; the TO-3 at 1A and 20W.

features

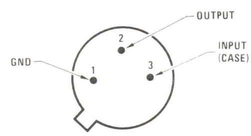
- Preset output voltage error less than ±3%
- Preset current limit
- Internal thermal shutdown
- Operates with input-output voltage differential down to 1V
- Excellent ripple rejection
- 50 mV load regulation

schematic and connection diagrams

−5V & −5.2V



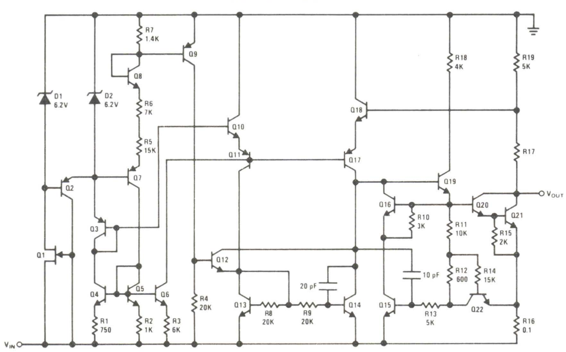
TO-5 (H)



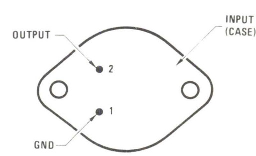
BOTTOM VIEW

Order Numbers:
LM120H-05 LM120H-5.2 LM120H-12 LM120H-15
LM220H-05 LM220H-5.2 LM220H-12 LM220H-15
LM320H-05 LM320H-5.2 LM320H-12 LM320H-15
See Package 9

−12V & −15V



TO-3 (K)



BOTTOM VIEW

Order Numbers:
LM120K-05 LM120K-5.2 LM120K-12 LM120K-15
LM220K-05 LM220K-5.2 LM220K-12 LM220K-15
LM320K-05 LM320K-5.2 LM320K-12 LM320K-15
See Package 18

absolute maximum ratings

Device Type	Input Voltage	Input-Output Differential
LM120 Series/-5.0V	−25V	25V
LM120 Series/-5.2V	−25V	25V
LM120 Series/-12V	−35V	30V
LM120 Series/-15V	−40V	30V

Power Dissipation	Internally Limited
Operating Junction Temperature Range	
LM120	−55°C to +150°C
LM220	−25°C to +150°C
LM320	0°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering 10 sec)	300°C

electrical characteristics (−5V & −5.2V) (Note 1)

PARAMETER	CONDITIONS	LM120 LM220 MIN	LM120 LM220 MAX	TYP	LM320 MIN	LM320 MAX	UNITS
Output Voltage	$T_j = 25°C$ −5V	−5.1	−4.9	−5.0	−5.2	−4.8	V
	−5.2V	−5.3	−5.1	−5.2	−5.4	−5.0	V
Line Regulation (Note 2)	$T_j = 25°C$, $-25V \leq V_{IN} \leq -7V$		25	10		50	mV
Load Regulation (Note 2)	$T_j = 25°C$						
H Package	$5\text{ mA} \leq I_{OUT} \leq 0.5A$		50	20		50	mV
K Package	$5\text{ mA} \leq I_{OUT} \leq 1.5A$		75	50		100	mV
Output Voltage	$-25V \leq V_{IN} \leq -7V$, $5\text{ mA} \leq I_{OUT} \leq I_{MAX}$						
	$P \leq P_{MAX}$ −5V	−5.20	−4.80		−5.25	−4.75	V
	−5.2V	−5.40	−5.00		−5.45	−4.95	V
Quiescent Current	$-25V \leq V_{IN} \leq -7V$		2.0	1.0		2.0	mA
Quiescent Current Change	$T_A = 25°C$						
	$-25V \leq V_{IN} \leq -7V$		0.4	0.1		0.4	mA
	$5\text{ mA} \leq I_{OUT} \leq I_{MAX}$		0.4	0.1		0.4	mA
Output Noise Voltage	$T_A = 25°C$, $C_L = 1\ \mu F$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$			150			µV
Long Term Stability			50	5		50	mV
Thermal Resistance Junction to Case							
H Package				15			°C/W
K Package				3			°C/W

electrical characteristics (−12V) (Note 1)

PARAMETER	CONDITIONS	LM120 LM220 MIN	LM120 LM220 MAX	TYP	LM320 MIN	LM320 MAX	UNITS
Output Voltage	$T_j = 25°C$	−12.3	−11.7	−12	−12.4	−11.6	V
Line Regulation (Note 2)	$T_j = 25°C$, $-32V \leq V_{IN} \leq -14V$		10	4		20	mV
Load Regulation (Note 2)	$T_j = 25°C$						
H Package	$5\text{ mA} \leq I_{OUT} \leq 0.2A$		25	10		40	mV
K Package	$5\text{ mA} \leq I_{OUT} \leq 1.0A$		80	30		80	mV
Output Voltage	$-32V \leq V_{IN} \leq -14V$, $5\text{ mA} \leq I_{OUT} \leq I_{MAX}$, $P \leq P_{MAX}$	−12.5	−11.5		−12.6	−11.4	V
Quiescent Current	$-32V \leq V_{IN} \leq -14V$		4	2		4	mA
Quiescent Current Change	$T_j = 25°C$						
	$-32V \leq V_{IN} \leq -14V$			0.1			mA
	$5\text{ mA} \leq I_{OUT} \leq I_{MAX}$			0.1			mA
Output Noise Voltage	$T_A = 25°C$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$			400			µV
Long Term Stability			120	15		120	mV

electrical characteristics (–15V) (Note 1)

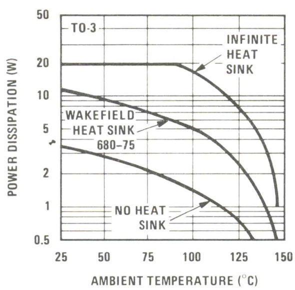
PARAMETER	CONDITIONS	LM120 LM220 MIN	LM120 LM220 MAX	TYP	LM320 MIN	LM320 MAX	UNITS
Output Voltage	$T_j = 25^\circ C$	–15.3	–14.7	–15	–15.4	–14.6	V
Line Regulation (Note 2)	$T_j = 25^\circ C$ $-35V \leq V_{IN} \leq -17V$		10	5		20	mV
Load Regulation	$T_j = 25^\circ C$						
H Package (Note 2)	$5\ mA \leq I_{OUT} \leq 0.2A$		25	10		40	mV
K Package (Note 2)	$5\ mA \leq I_{OUT} \leq 1.0A$		80	30		80	mV
Output Voltage	$-35V \leq V_{IN} \leq -17V$ $5\ mA \leq I_{OUT} \leq I_{MAX}$ $P \leq P_{MAX}$	15.5	14.5		15.6	14.4	V
Quiescent Current	$-35V \leq V_{IN} \leq -17V$		4	2		4	mA
Quiescent Current Change	$T_j = 25^\circ C$ $-35V \leq V_{IN} \leq -17V$ $5\ mA \leq I_{OUT} \leq I_{MAX}$			 0.1 0.1			mA
Output Noise Voltage				400			µV
Long Term Stability			150	15		150	mV

Note 1: Unless otherwise specified, these specifications apply: $-55^\circ C < T_j < 150^\circ C$ for the LM120; $-25^\circ C < T_j < 150^\circ C$ for the LM220, and $0^\circ C < T_j < 125^\circ C$ for the LM320; $V_{IN} = (V_{OUT} + 5V)$ and $I_{OUT} = 0.1A$ for the TO-5 package and $I_{OUT} = 0.5A$ for the TO-3 package. For the TO-5 package, $I_{MAX} = 0.2A$ and $P_{MAX} = 2.0W$. For the TO-3 package, $I_{MAX} = 1.0A$ and $P_{MAX} = 20W$. Although power dissipation is internally limited, electrical specifications apply only for power levels up to P_{MAX}. For calculations of junction temperature rise due to power dissipation, use a thermal resistance of 150°C/W for the TO-5 and 35°C/W for the TO-3. With an infinite heat sink, the thermal resistance is 15°C/W and 3°C/W respectively.

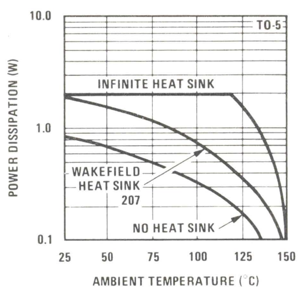
Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. To ensure constant junction temperature, pulse testing with a low duty cycle is used.

typical performance characteristics

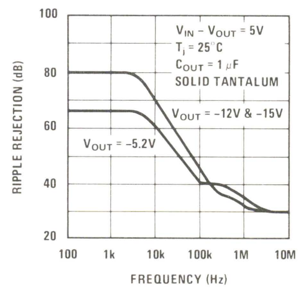
Maximum Average Power Dissipation



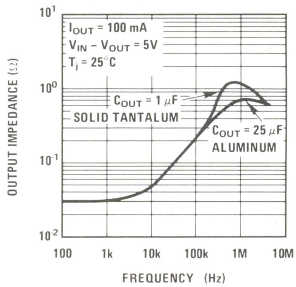
Maximum Average Power Dissipation



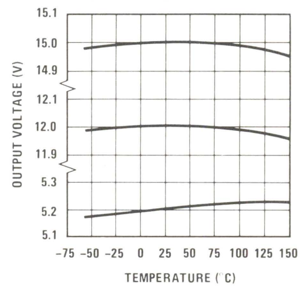
Ripple Rejection



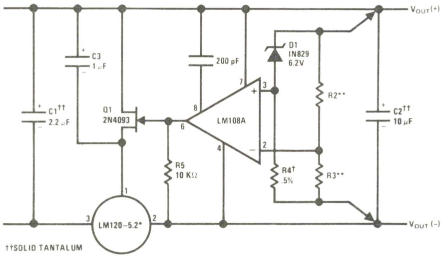
Output Impedance



Output Voltage



typical applications



††SOLID TANTALUM

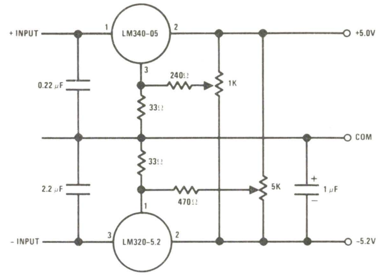
LOAD & LINE REGULATION <0.01% TEMPERATURE STABILITY <0.1%

†DETERMINES ZENER CURRENT. MAY BE ADJUSTED TO MINIMIZE TEMPERATURE DRIFT

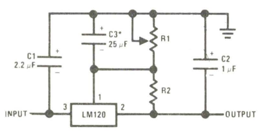
**SELECT RESISTORS TO SET OUTPUT VOLTAGE. 1 PPM/°C TRACKING SUGGESTED.

*AN LM120-12 OR LM120-15 MAY BE USED TO PERMIT HIGHER INPUT VOLTAGES, BUT THE REGULATED OUTPUT VOLTAGE MUST BE AT LEAST −15V WHEN USING THE LM120-12 AND −18V FOR THE LM120-15.

High Stability 1 Amp Regulator



Dual Trimmed Supply

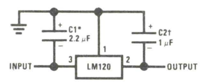


*Optional. Improves transient response and ripple rejection.

$V_{OUT} = V_{SET}\left(\frac{R1 + R2}{R2}\right)$

SELECT R2 AS FOLLOWS
LM120-5 – 300Ω
LM120-5.2 – 300Ω
LM120-12 – 750Ω
LM120-15 – 1 KΩ

Variable Output

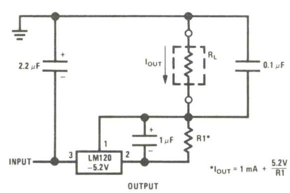


* REQUIRED IF REGULATOR IS SEPARATED FROM FILTER CAPACITOR. FOR VALUE GIVEN, CAPACITOR MUST BE SOLID TANTALUM. 25μF ALUMINUM ELECTROLYTIC MAY BE SUBSTITUTED.

† REQUIRED FOR STABILITY. FOR VALUE GIVEN, CAPACITOR MUST BE SOLID TANTALUM. 25μF ALUMINUM ELECTROLYTIC MAY BE SUBSTITUTED. VALUES GIVEN MAY BE INCREASED WITHOUT LIMIT.

FOR OUTPUT CAPACITANCE IN EXCESS OF 100 μF, A HIGH CURRENT DIODE FROM INPUT TO OUTPUT (1N4001, ETC) WILL PROTECT THE REGULATOR FROM MOMENTARY INPUT SHORTS.

Fixed Regulator



$*I_{OUT} = 1\ mA + \frac{5.2V}{R1}$

Current Source

LM123/LM223/LM323 3 amp-5 volt positive regulator

general description

The LM123 is a three-terminal positive regulator with a preset 5V output and a load driving capability of 3 amps. New circuit design and processing techniques are used to provide the high output current without sacrificing the regulation characteristics of lower current devices.

The 3 amp regulator is virtually blowout proof. Current limiting, power limiting, and thermal shutdown provide the same high level of reliability obtained with these techniques in the LM109 1 amp regulator.

No external components are required for operation of the LM123. If the device is more than 4 inches from the filter capacitor, however, a 1µF solid tantalum capacitor should be used on the input. A 0.1µF or larger capacitor may be used on the output to reduce load transient spikes created by fast switching digital logic, or to swamp out stray load capacitance.

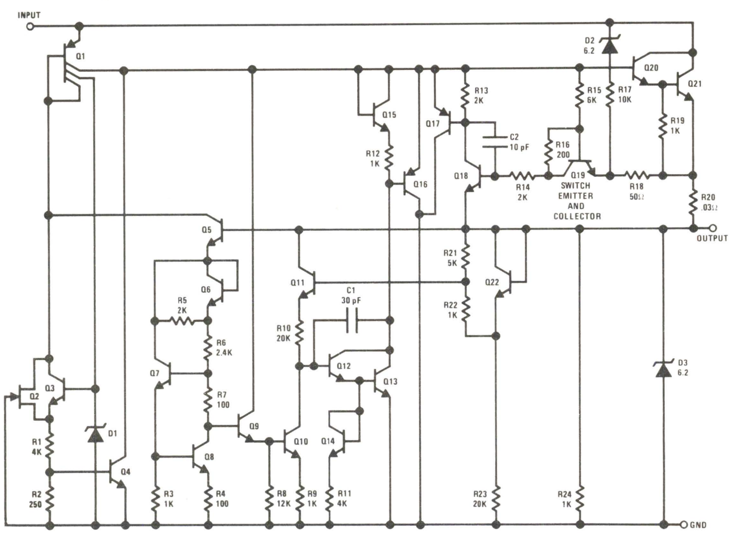
An overall worst case specification for the combined effects of input voltage, load currents, ambient temperature, and power dissipation ensure that the LM123 will perform satisfactorily as a system element.

Operation is guaranteed over the junction temperature range −55°C to +150°C. An electrically identical LM223 operates from −25°C to +150°C and the LM323 is specified from 0°C to +125°C junction temperature. A hermetic TO-3 package is used for high reliability and low thermal resistance.

features

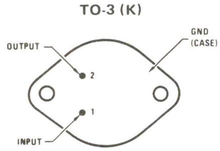
- 3 amp output current
- Internal current and thermal limiting
- 0.01Ω typical output impedance
- 7.5 minimum input voltage
- 30W power dissipation

schematic diagram



connection diagram

TO-3 (K)



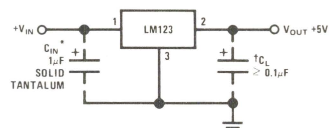
BOTTOM VIEW

Order Number LM123K, LM223K, or LM323K

See Package 18

typical applications

Basic 3 Amp Regulator



*REQUIRED IF LM123 IS MORE THAN 4" FROM FILTER CAPACITOR
†REGULATOR IS STABLE WITH NO LOAD CAPACITOR INTO RESISTIVE LOADS

absolute maximum ratings

Input Voltage	20V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	
LM123	−55°C to +150°C
LM223	−25°C to +150°C
LM323	0°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LM123/LM223			LM323			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	$T_j = 25°C$ $V_{IN} = 7.5V$, $I_{OUT} = 0$	4.7	5	5.3	4.8	5	5.2	V
Output Voltage	$7.5V \leq V_{IN} \leq 15V$ $0 \leq I_{OUT} \leq 3A$, $P \leq 30W$	4.6		5.4	4.75		5.25	V
Line Regulation (Note 3)	$T_j = 25°C$ $7.5V \leq V_{IN} \leq 15V$		5	25		5	25	mV
Load Regulation (Note 3)	$T_j = 25°C$, $V_{IN} = 7.5V$, $0 \leq I_{OUT} \leq 3A$		25	100		25	100	mV
Quiescent Current	$7.5V \leq V_{IN} \leq 15V$, $0 \leq I_{OUT} \leq 3A$		12	20		12	20	mA
Output Noise Voltage	$T_j = 25°C$ $10\ Hz \leq f \leq 100\ kHz$		40			40		μVrms
Short Circuit Current Limit	$T_j = 25°C$ $V_{IN} = 15V$ $V_{IN} = 7.5V$		3 4	4.5 5		3 4	4.5 5	A A
Long Term Stability				35			35	mV
Thermal Resistance Junction to Case (Note 2)			2			2		°C/W

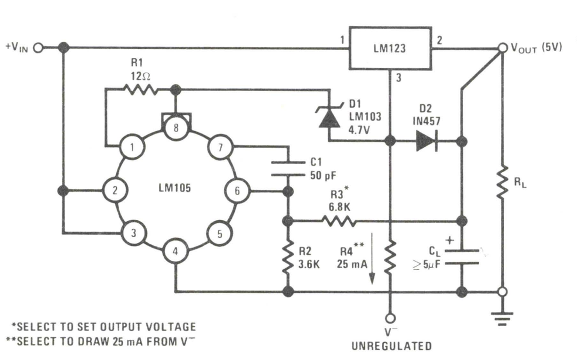
Note 1: Unless otherwise noted, specifications apply for $-55°C \leq T_j \leq +150°C$ for the LM123, $-25°C \leq T_j \leq +150°C$ for the LM223, and $0°C \leq T_j \leq +125°C$ for the LM323. Although power dissipation is internally limited, specifications apply only for $P \leq 30W$.

Note 2: Without a heat sink, the thermal resistance of the TO-3 package is about 35°C/W. With a heat sink, the effective thermal resistance can only approach the specified values of 2°C/W, depending on the efficiency of the heat sink.

Note 3: Load and line regulation are specified at constant junction temperature. Pulse testing is required with a pulse width ≤ 1 ms and a duty cycle ≤ 5%.

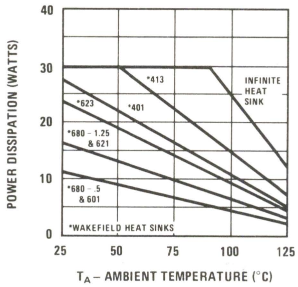
typical applications (con't)

Adjustable Output 5V – 10V 0.1% Regulation

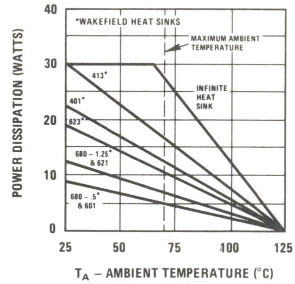


typical performance characteristics

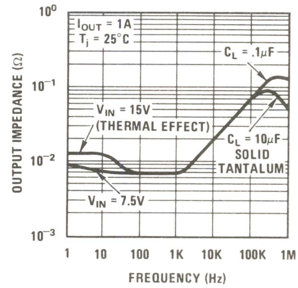
Maximum Average Power Dissipation For LM123; LM223



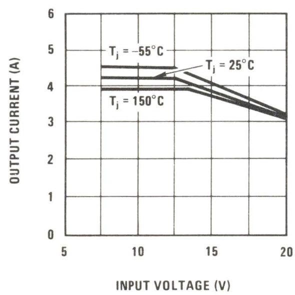
Maximum Average Power Dissipation For LM323



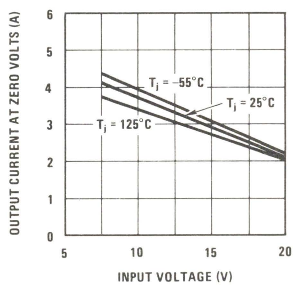
Output Impedance



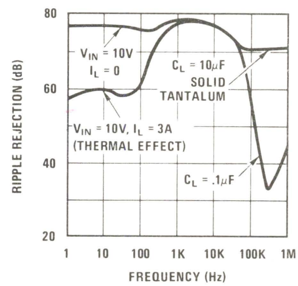
Peak Available Output Current



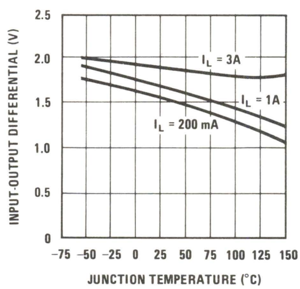
Short Circuit Current



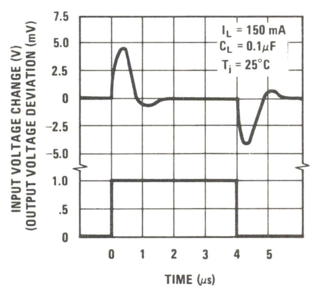
Ripple Rejection



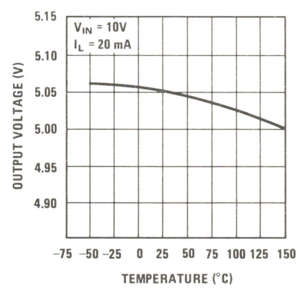
Dropout Voltage



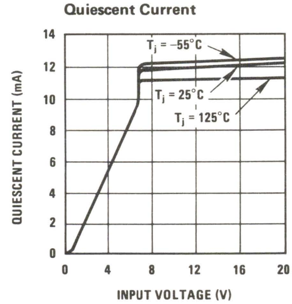
Line Transient Response



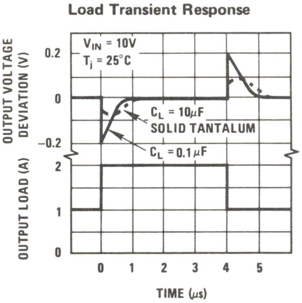
Output Voltage



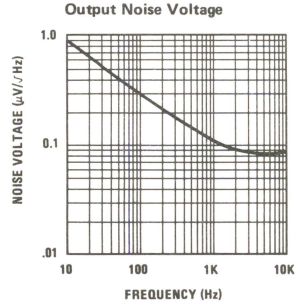
Quiescent Current



Load Transient Response



Output Noise Voltage



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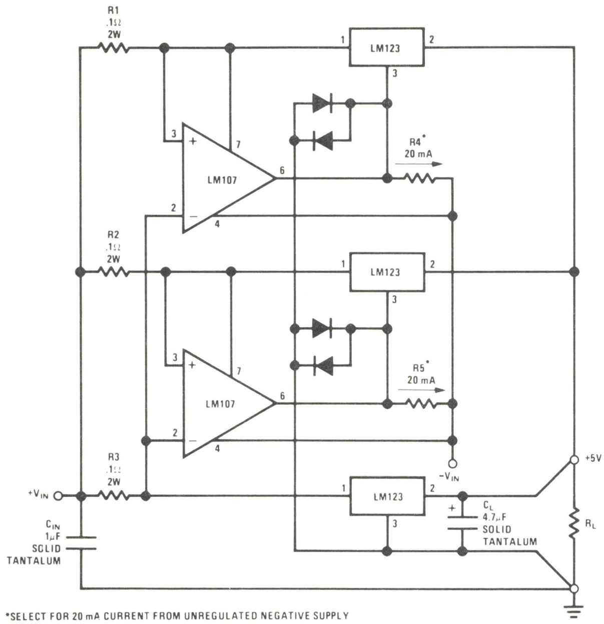
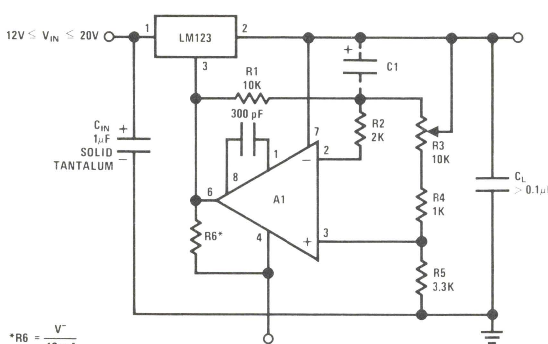
typical applications (con't)

10 Amp Regulator With Complete Overload Protection



*SELECT FOR 20 mA CURRENT FROM UNREGULATED NEGATIVE SUPPLY

Adjustable Regulator 0–10V @ 3A

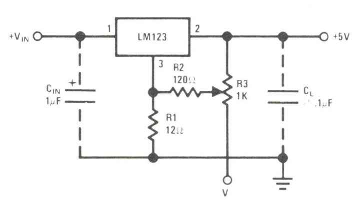


$*R6 = \frac{V^-}{12\text{ mA}}$

V^- (−10V TO 20V)
NEED NOT BE REGULATED

A_1 – LM101A
C_1 – 2μF OPTIONAL – IMPROVES RIPPLE REJECTION, NOISE, AND TRANSIENT RESPONSE

Trimming Output to 5V



Voltage Regulators

LM340 series 3-terminal positive regulators

general description

The LM340-XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM340-XX series is available in two power packages. Both the plastic TO-220 and metal TO-3 packages allow these regulators to deliver over 1.0A if adequate heat sinking is provided. Even with over 1.0A of output current available the regulators are essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expended to make the LM340-XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

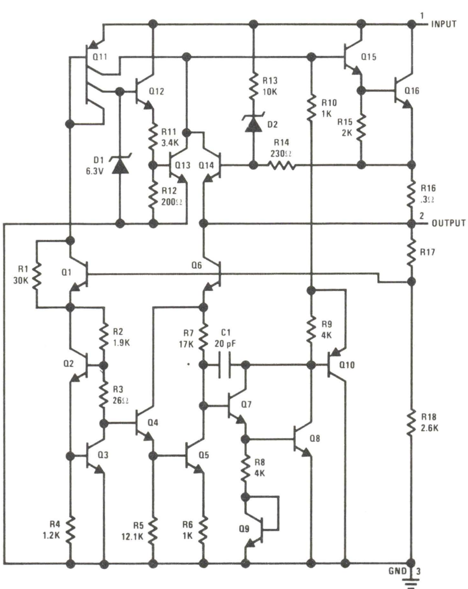
features

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-220 and metal TO-3 packages

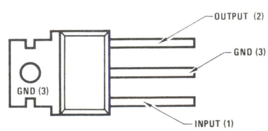
voltage range

LM340-5	5V	LM340-15	15V
LM340-6	6V	LM340-18	18V
LM340-8	8V	LM340-24	24V
LM340-12	12V		

schematic and connection diagrams



TO-220 (T)



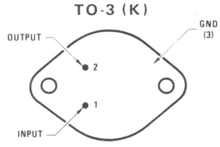
TOP VIEW

Order Numbers:

LM340T-5	**LM340T-15**
LM340T-6	**LM340T-18**
LM340T-8	**LM340T-24**
LM340T-12	

See Package 26

TO-3 (K)



BOTTOM VIEW

Order Numbers:

LM340K-5	**LM340K-15**
LM340K-6	**LM340K-18**
LM340K-8	**LM340K-24**
LM340K-12	

See Package 18

absolute maximum ratings

Input Voltage (V_O = 5V through 18V)	35V
(V_O = 24V)	40V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range	0°C to 70°C
Maximum Junction Temperature	
TO-3 Package	150°C
TO-220 Package	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature	
TO-3 Package (Soldering, 10 sec)	300°C
TO-220 Package (Soldering, 10 sec)	230°C

electrical characteristics

LM340-5 (V_{IN} = 10V, I_{OUT} = 500 mA, $0°C \leq T_A \leq 70°C$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	T_j = 25°C	4.8	5	5.2	V
Line Regulation	T_j = 25°C, $7V \leq V_{IN} \leq 25V$				
	I_{OUT} = 100 mA			50	mV
	I_{OUT} = 500 mA			100	mV
Load Regulation	T_j = 25°C, $5\ mA \leq I_{OUT} \leq 1.5A$			100	mV
Output Voltage	$7V \leq V_{IN} \leq 20V$, $5\ mA \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	4.75		5.25	V
Quiescent Current	T_j = 25°C		7	10	mA
Quiescent Current Change	$7V \leq V_{IN} \leq 25V$			1.3	mA
	$5\ mA \leq I_{OUT} \leq 1.5A$			.5	mA
Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		40		µV
Long Term Stability				20	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		60		dB
Dropout Voltage	T_j = 25°C, I_{OUT} = 1.0A		2		V

LM340-6 (V_{IN} = 11V, I_{OUT} = 500 mA, $0°C \leq T_A \leq 70°C$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	T_j = 25°C	5.75	6	6.25	V
Line Regulation	T_j = 25°C, $8V \leq V_{IN} \leq 25V$				
	I_{OUT} = 100 mA			60	mV
	I_{OUT} = 500 mA			120	mV
Load Regulation	T_j = 25°C, $5\ mA \leq I_{OUT} \leq 1.5A$			120	mV
Output Voltage	$8V \leq V_{IN} \leq 21V$, $5\ mA \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	5.7		6.3	V
Quiescent Current	T_j = 25°C		7	10	mA
Quiescent Current Change	$8V \leq V_{IN} \leq 25V$			1.3	mA
	$5\ mA \leq I_{OUT} \leq 1.5A$			.5	mA
Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		45		µV
Long Term Stability				24	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		57		dB
Dropout Voltage	T_j = 25°C, I_{OUT} = 1.0A		2		V

Note 1: Thermal resistance without a heat sink for junction to case temperature is 4°C/W for the TO-3 package and 6°C/W for the TO-220 package. Thermal resistance for case to ambient temperature is 35°C/W for the TO-3 package and 50°C/W for the TO-220 package.

electrical characteristics (con't)

LM340-8 (V_{IN} = 14V, I_{OUT} = 500 mA, $0°C \leq T_A \leq 70°C$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25°C$	7.7	8	8.3	V
Line Regulation	$T_j = 25°C$, $10.5V \leq V_{IN} \leq 25V$				
	I_{OUT} = 100 mA			80	mV
	I_{OUT} = 500 mA			160	mV
Load Regulation	$T_j = 25°C$, 5 mA $\leq I_{OUT} \leq$ 1.5A			160	mV
Output Voltage	$10.5V \leq V_{IN} \leq 23V$, 5 mA $\leq I_{OUT} \leq$ 1.0A $P_D \leq 15W$	7.6		8.4	V
Quiescent Current	$T_j = 25°C$		7	10	mA
Quiescent Current Change	$10.5V \leq V_{IN} \leq 25V$			1	mA
	5 mA $\leq I_{OUT} \leq$ 1.5A			.5	mA
Output Noise Voltage	$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz		52		μV
Long Term Stability				32	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		55		dB
Dropout Voltage	$T_j = 25°C$, I_{OUT} = 1.0A		2		V

LM340-12 (V_{IN} = 19V, I_{OUT} = 500 mA, $0°C \leq T_A \leq 70°C$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25°C$	11.5	12	12.5	V
Line Regulation	$T_j = 25°C$, $14.5V \leq V_{IN} \leq 30V$				
	I_{OUT} = 100 mA			120	mV
	I_{OUT} = 500 mA			240	mV
Load Regulation	$T_j = 25°C$, 5 mA $\leq I_{OUT} \leq$ 1.5A			240	mV
Output Voltage	$14.5V \leq V_{IN} \leq 27V$, 5 mA $\leq I_{OUT} \leq$ 1.0A $P_D \leq 15W$	11.4		12.6	V
Quiescent Current	$T_j = 25°C$		7	10	mA
Quiescent Current Change	$14.5V \leq V_{IN} \leq 30V$			1	mA
	5 mA $\leq I_{OUT} \leq$ 1.5A			.5	mA
Output Noise Voltage	$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz		75		μV
Long Term Stability				48	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		52		dB
Dropout Voltage	$T_j = 25°C$, I_{OUT} = 1.0A		2		V

LM340-15 (V_{IN} = 23V, I_{OUT} = 500 mA, $0°C \leq T_A \leq 70°C$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25°C$	14.4	15	15.6	V
Line Regulation	$T_j = 25°C$, $17.5V \leq V_{IN} \leq 30V$				
	I_{OUT} = 100 mA			150	mV
	I_{OUT} = 500 mA			300	mV
Load Regulation	$T_j = 25°C$, 5 mA $\leq I_{OUT} \leq$ 1.5A			300	mV
Output Voltage	$17.5V \leq V_{IN} \leq 30V$, 5 mA $\leq I_{OUT} \leq$ 1.0A $P_D \leq 15W$	14.25		15.75	V
Quiescent Current	$T_j = 25°C$		7	10	mA
Quiescent Current Change	$17.5V \leq V_{IN} \leq 30V$			1	mA
	5 mA $\leq I_{OUT} \leq$ 1:5A			.5	mA
Output Noise Voltage	$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz		90		μV
Long Term Stability				60	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		50		dB
Dropout Voltage	$T_j = 25°C$, I_{OUT} = 1.0A		2		V

1

electrical characteristics (con't)

LM340-18 (V_{IN} = 27V, I_{OUT} = 500 mA, 0°C ≤ T_A ≤ 70°C, unless otherwise specified)

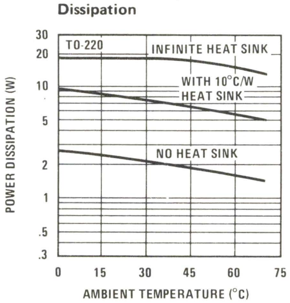
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	T_j = 25°C	17.3	18	18.7	V
Line Regulation	T_j = 25°C, 21V ≤ V_{IN} ≤ 33V				
	I_{OUT} = 100 mA			180	mV
	I_{OUT} = 500 mA			360	mV
Load Regulation	T_j = 25°C, 5 mA ≤ I_{OUT} ≤ 1.0A			360	mV
Output Voltage	21V ≤ V_{IN} ≤ 33V, 5 mA ≤ I_{OUT} ≤ 1.0A P_D ≤ 15W	17.1		18.9	V
Quiescent Current	T_j = 25°C		7	10	mA
Quiescent Current Change	21V ≤ V_{IN} ≤ 33V			1	mA
	5 mA ≤ I_{OUT} ≤ 1.0A			.5	mA
Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		110		μV
Long Term Stability				72	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		48		dB
Dropout Voltage	T_j = 25°C, I_{OUT} = 1.0A		2		V

LM340-24 (V_{IN} = 33V, I_{OUT} = 500 mA, 0°C ≤ T_A ≤ 70°C, unless otherwise specified)

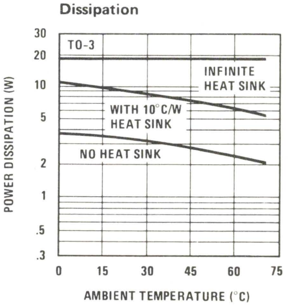
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	T_j = 25°C	23	24	25	V
Line Regulation	T_j = 25°C, 27V ≤ V_{IN} ≤ 38V				
	I_{OUT} = 100 mA			240	mV
	I_{OUT} = 500 mA			480	mV
Load Regulation	T_j = 25°C, 5 mA ≤ I_{OUT} ≤ 1.0A			480	mV
Output Voltage	27V ≤ V_{IN} ≤ 38V, 5 mA ≤ I_{OUT} ≤ 1.0A P_D ≤ 15W	22.8		25.2	V
Quiescent Current	T_j = 25°C		7	10	mA
Quiescent Current Change	27V ≤ V_{IN} ≤ 38V			1	mA
	5 mA ≤ I_{OUT} ≤ 1.0A			.5	mA
Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		170		μV
Long Term Stability				96	mV/1000 hr
Ripple Rejection	I_{OUT} = 20 mA, f = 120 Hz		44		dB
Dropout Voltage	T_j = 25°C, I_{OUT} = 1.0A		2		V

typical performance characteristics

Maximum Average Power Dissipation

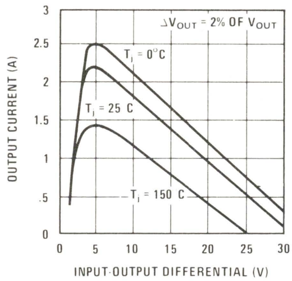


Maximum Average Power Dissipation

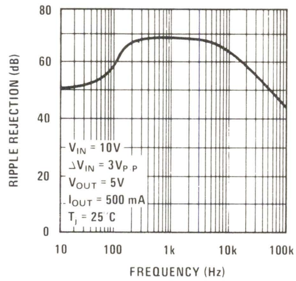


typical performance characteristics (con't)

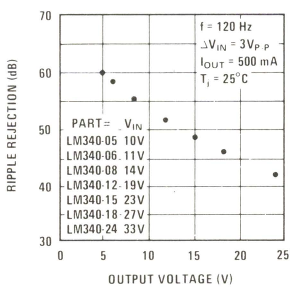
Peak Output Current



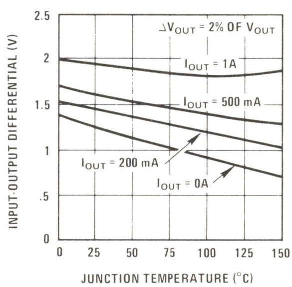
Ripple Rejection



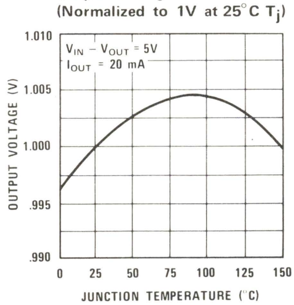
Ripple Rejection



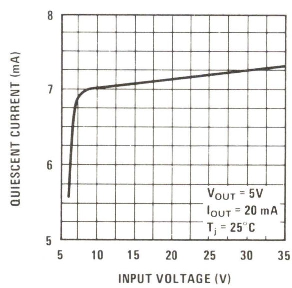
Dropout Voltage



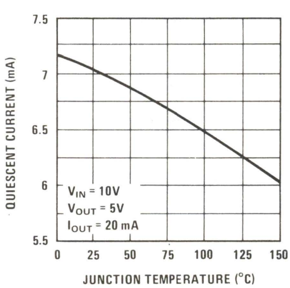
Output Voltage (Normalized to 1V at 25°C T_j)



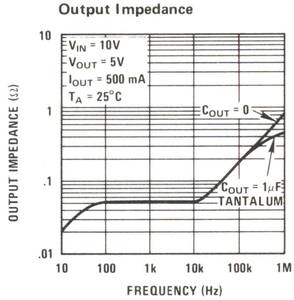
Quiescent Current



Quiescent Current

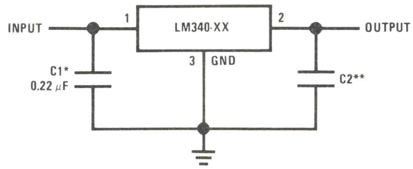


Output Impedance



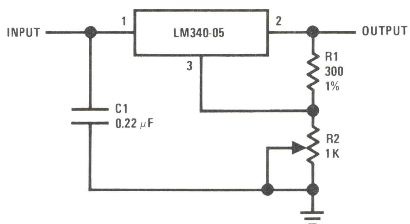
typical applications

Fixed Output Regulator



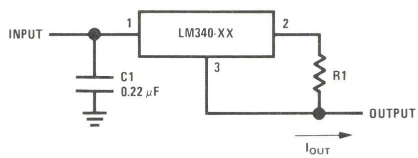
*REQUIRED IF THE REGULATOR IS LOCATED FAR FROM THE POWER SUPPLY FILTER.
**ALTHOUGH NO OUTPUT CAPACITOR IS NEEDED FOR STABILITY, IT DOES HELP TRANSIENT RESPONSE. (IF NEEDED USE 0.1μF, CERAMIC, DISC.)

Adjustable Output Regulator



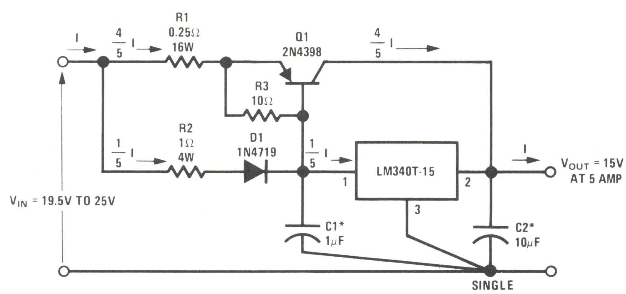
$V_{OUT} = 5V + (16.7\ mA + I_Q)\ R_2$
$\Delta I_Q = 1.5\ mA$ over line and load changes

Current Regulator



$I_{OUT} = \frac{V_{2\text{-}3}}{R_1} + I_Q$
$\Delta I_Q = 1.5\ mA$ over line and load changes

15V 5 Amp Regulator With Short Circuit Current Limit



*SOLID TANTALUM

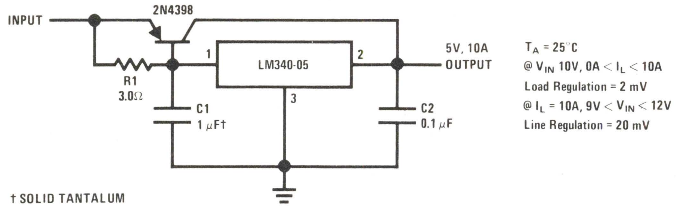
NOTE 1: CURRENT SHARING BETWEEN THE LM340 AND Q1 ALLOWS THE EXTENSION OF SHORT CIRCUIT CURRENT LIMIT, SAFE OPERATING AREA PROTECTION, AND (ASSUMING Q1'S HEAT SINK HAS FOUR OR MORE TIMES THE CAPACITY OF THE LM340 HEAT SINK) THERMAL SHUTDOWN PROTECTION.

NOTE 2: $I_{SHORT\ CIRCUIT}$ IS APPROXIMATELY 5.5 AMP.

NOTE 3: $I_{OUT\ MAX}$ AT V_{OUT} = 15V IS APPROXIMATELY 9.5 AMP.

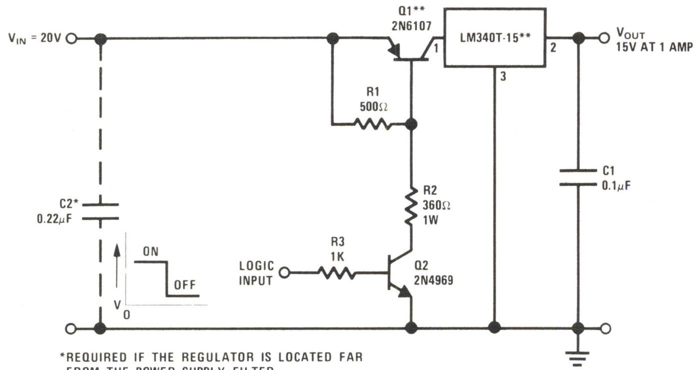
typical applications (con't)

High Current Voltage Regulator



† SOLID TANTALUM

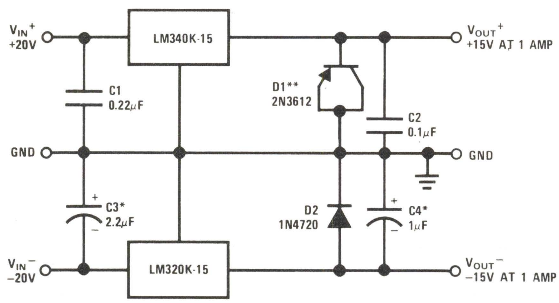
Electronic Shutdown Circuit



*REQUIRED IF THE REGULATOR IS LOCATED FAR FROM THE POWER SUPPLY FILTER

**HEAT SINK Q1 AND THE LM340

Dual Power Supply



*SOLID TANTALUM

**GERMANIUM DIODE (USING A PNP GERMANIUM TRANSISTOR WITH THE COLLECTOR SHORTED TO THE EMITTER)

NOTE 1: DIODES D1 AND D2 ASSURE REGULATOR STARTUP INTO A COMMON LOAD REGARDLESS OF THE INPUT VOLTAGE STARTUP SEQUENCE.

Voltage Regulators

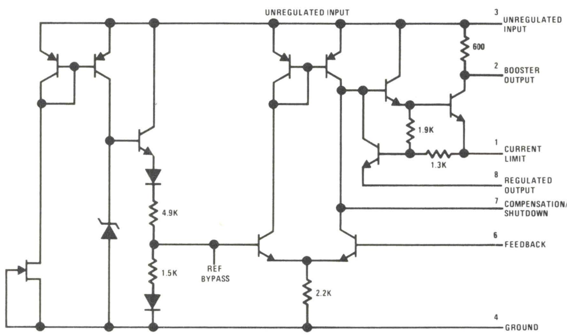
LM376 voltage regulator

general description

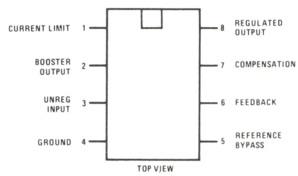
The LM376 is a positive voltage regulator designed primarily for commercial product applications. The device is especially useful because it is packaged in an 8-pin mini-DIP which has the advantage of reduced size and low cost. Used independently, the device will supply 25 mA; but with the addition of external pass elements any desired load current can be achieved. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics of the LM376 are:

- Output voltage range +5V to 37V
- Output current 25 mA
- Load regulation 0.2%
- Line regulation 0.03%/V

simplified schematic and connection diagrams



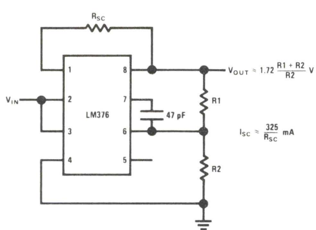
Dual-In-Line Package



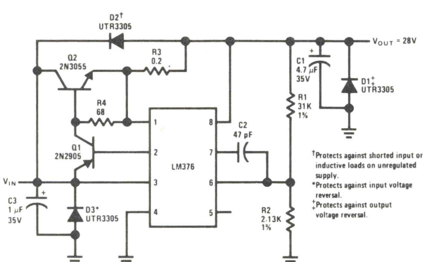
Order Number LM376N
See Package 20

typical applications

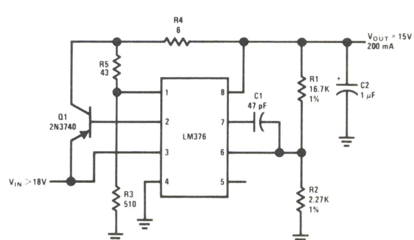
Basic Positive Regulator with Current Limiting



1.0A Regulator with Protective Diodes



Linear Regulator with Foldback Current Limiting



absolute maximum ratings

Input Voltage	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	400 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

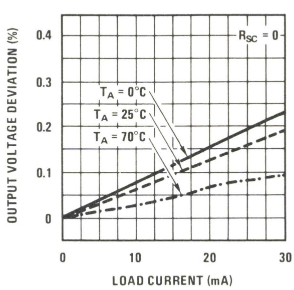
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		9.0		40	V
Output Voltage Range		5.0		37	V
Output-Input Voltage Differential		3.0		30	V
Load Regulation	$0 \leq I_O \leq 25$ mA				
	$R_{SC} = 0\Omega$, $T_A = 25°C$			0.2	%
	$R_{SC} = 0\Omega$, $T_A = 70°C$			0.5	%
	$R_{SC} = 0\Omega$, $T_A = 0°C$			0.5	%
Line Regulation	$T_A = 25°C$			.03	%/V
				.1	%/V
Ripple Rejection	f = 120 Hz, $T_A = 25°C$			0.1	%/V
Standby Current Drain	$V_{IN} = 30V$, $T_A = 25°C$			2.5	mA
Reference Voltage		1.60	1.72	1.80	V
Current Limit Sense Voltage			.360		V

Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 187°C/W junction to ambient.

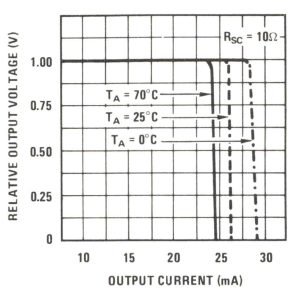
Note 2: These specifications apply for an operating temperature between 0°C and 70°.

typical performance characteristics

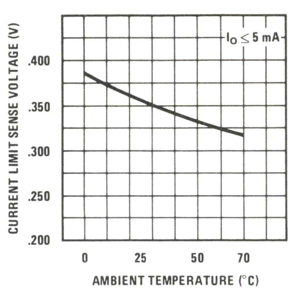
Load Regulation



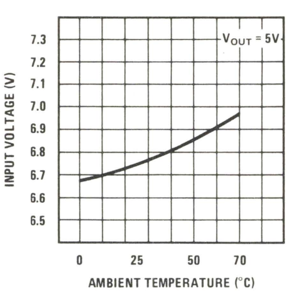
Current Limiting Characteristics



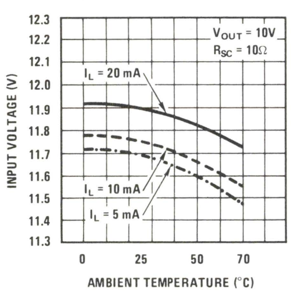
Current Limit Sense Voltage



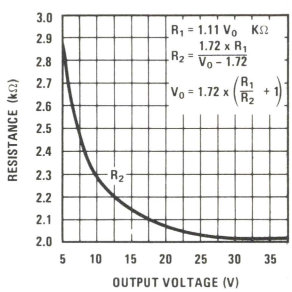
Minimum Input Voltage



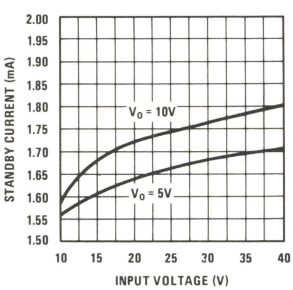
Regulator Dropout Voltage



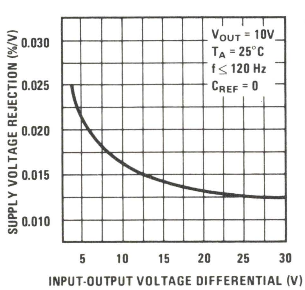
Optimum Divider Resistance



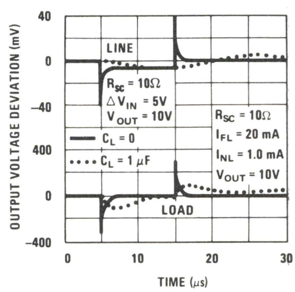
Standby Current Drain
T_A = 25°C



Supply Voltage Rejection



Transient Response



Voltage Regulators

LM723/LM723C voltage regulator

general description

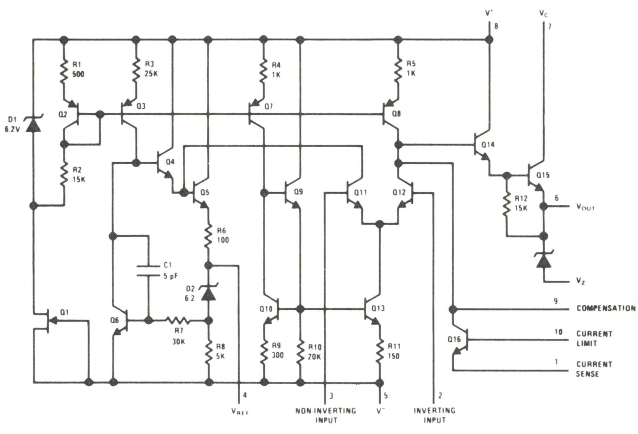
The LM723/LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics are:

- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator.

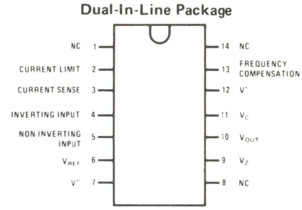
The LM723/LM723C is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

The LM723C is identical to the LM723 except that the LM723C has its performance guaranteed over a 0°C to 70°C temperature range, instead of −55°C to +125°C.

schematic and connection diagrams *



Dual-In-Line Package

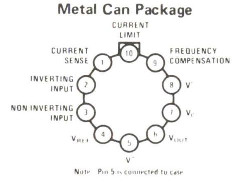


TOP VIEW

Order Number LM 723D or LM723CD
See Package 1

Order Number LM723N or LM723CN
See Package 22

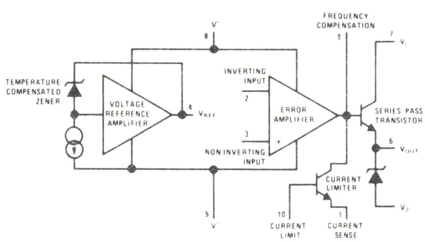
Metal Can Package



TOP VIEW

Order Number LM723H or LM723CH
See Package 13

equivalent circuit *



* Pin numbers for metal can package only
Note 7

absolute maximum ratings

Pulse Voltage from V^+ to V^- (50 ms)	50V
Continuous Voltage from V^+ to V^-	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	7.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can (Note 1)	800 mW
Cavity DIP (Note 1)	900 mW
Molded DIP (Note 1)	660 mW
Operating Temperature Range LM723	−55°C to +125°C
LM723C	0°C to +70°C
Storage Temperature Range Metal Can	−65°C to +150°C
DIP	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	LM723			LM723C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	V_{IN} = 12V to V_{IN} = 15V		.01	0.1		.01	0.1	% V_{OUT}
	$-55°C \le T_A \le +125°C$			0.3				% V_{OUT}
	$0°C \le T_A \le +70°C$						0.3	% V_{OUT}
	V_{IN} = 12V to V_{IN} = 40V		.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	I_L = 1 mA to I_L = 50 mA		.03	0.15		.03	0.2	% V_{OUT}
	$-55°C \le T_A \le +125°C$			0.6				% V_{OUT}
	$0°C \le T_A \le = +70°C$						0.6	% V_{OUT}
Ripple Rejection	f = 50 Hz to 10 kHz, C_{REF} = 0		74			74		dB
	f = 50 Hz to 10 kHz, C_{REF} = 5 μF		86			86		dB
Average Temperature Coefficient of Output Voltage	$-55°C \le T_A \le +125°C$		.002	.015				%/°C
	$0°C \le T_A \le +70°C$					.003	.015	%/°C
Short Circuit Current Limit	R_{SC} = 10Ω, V_{OUT} = 0		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	BW = 100 Hz to 10 kHz, C_{REF} = 0		20			20		μVrms
	BW = 100 Hz to 10 kHz, C_{REF} = 5 μF		2.5			2.5		μVrms
Long Term Stability			0.1			0.1		%/1000 hrs
Standby Current Drain	I_L = 0, V_{IN} = 30V		1.3	3.5		1.3	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V

Note 1: See derating curves for maximum power rating above 25°C.

Note 2: Unless otherwise specified, T_A = 25°C, $V_{IN} = V^+ = V_C$ = 12V, V^- = 0, V_{OUT} = 5V, I_L = 1 mA, R_{SC} = 0, C_1 = 100 pF, C_{REF} = 0 and divider impedance as seen by error amplifier $\le$ 10 kΩ connected as shown in Figure 1. Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.

Note 3: L_1 is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with 0.009 in. air gap.

Note 4: Figures in parentheses may be used if R1/R2 divider is placed on opposite input of error amp.

Note 5: Replace R1/R2 in figures with divider shown in Figure 13.

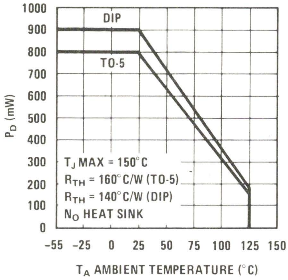
Note 6: V^+ must be connected to a +3V or greater supply.

Note 7: For metal can applications where V_Z is required, an external 6.2 volt zener diode should be connected in series with V_{OUT}.

maximum power ratings

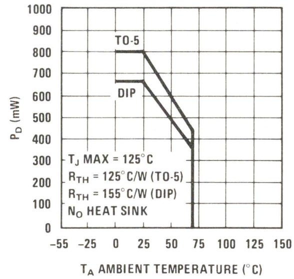
LM723

Power Dissipation vs Ambient Temperature



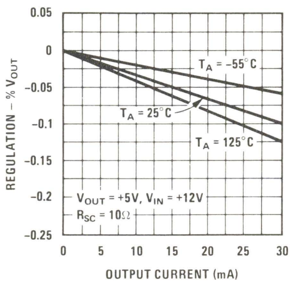
LM723C

Power Dissipation vs Ambient Temperature

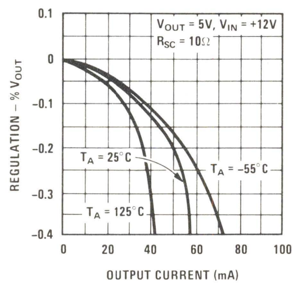


typical performance characteristics

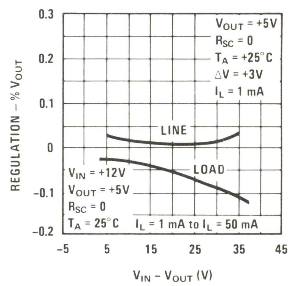
Load Regulation Characteristics with Current Limiting



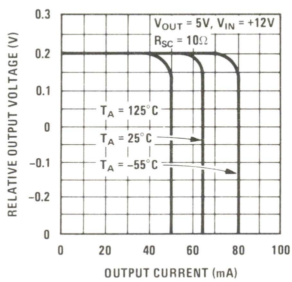
Load Regulation Characteristics with Current Limiting



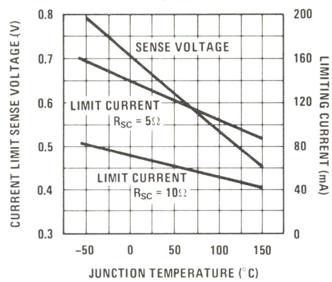
Load & Line Regulation vs Input-Output Voltage Differential



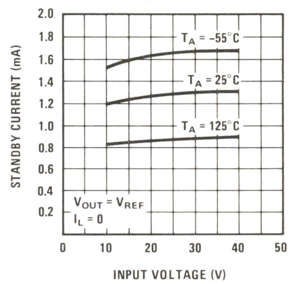
Current Limiting Characteristics



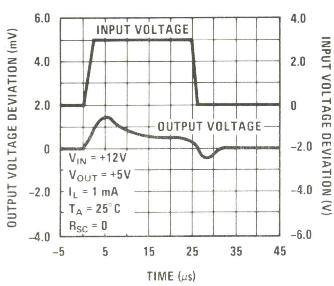
Current Limiting Characteristics vs Junction Temperature



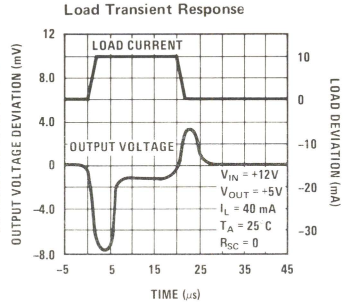
Standby Current Drain vs Input Voltage



Line Transient Response



Load Transient Response



Output Impedance vs Frequency

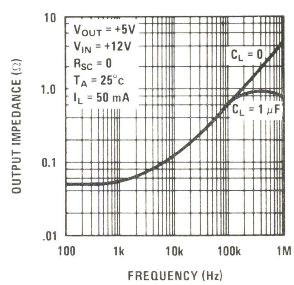


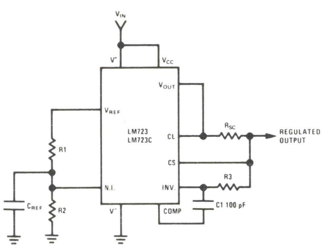
TABLE I RESISTOR VALUES (kΩ) FOR STANDARD OUTPUT VOLTAGE

POSITIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		OUTPUT ADJUSTABLE ±10% (Note 5)			NEGATIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		5% OUTPUT ADJUSTABLE ±10%		
	(Note 4)	R1	R2	R1	P1	R2			R1	R2	R1	P1	R2
+3.0	1, 5, 6, 9, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	102	2.2	10	91
+3.6	1, 5, 6, 9, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 12 (4)	2.15	4.99	.75	0.5	2.2	−6 (Note 6)	3, (10)	3.57	2.43	1.2	0.5	.75
+6.0	1, 5, 6, 9, 12 (4)	1.15	6.04	0.5	0.5	2.7	−9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 12, 9)	1.87	7.15	.75	1.0	2.7	−12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	−15	3, 10	3.65	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	−28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	−45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	−100	8	3.57	97.6	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	−250	8	3.57	249	2.2	10	240

TABLE II FORMULAE FOR INTERMEDIATE OUTPUT VOLTAGES

Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 12, (4)] $V_{OUT} = \left[V_{REF} \times \dfrac{R2}{R1 + R2}\right]$	**Outputs from +4 to +250 volts** [Figure 7] $V_{OUT} = \left[\dfrac{V_{REF}}{2} \times \dfrac{R2 - R1}{R1}\right]$; R3 = R4	**Current Limiting** $I_{LIMIT} = \dfrac{V_{SENSE}}{R_{SC}}$
Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 12)] $V_{OUT} = \left[V_{REF} \times \dfrac{R1 + R2}{R2}\right]$	**Outputs from −6 to −250 volts** [Figures 3, 8, 10] $V_{OUT} = \left[\dfrac{V_{REF}}{2} \times \dfrac{R1 + R2}{R1}\right]$; R3 = R4	**Foldback Current Limiting** $I_{KNEE} = \left[\dfrac{V_{OUT}\,R3}{R_{SC}\,R4} + \dfrac{V_{SENSE}\,(R3 + R4)}{R_{SC}\,R4}\right]$ $I_{SHORT\,CKT} = \left[\dfrac{V_{SENSE}}{R_{SC}} \times \dfrac{R3 + R4}{R4}\right]$

typical applications

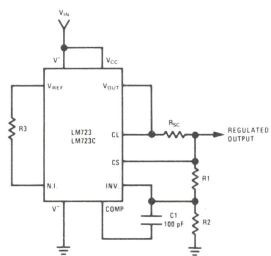


Note: $R3 = \dfrac{R1\,R2}{R1 + R2}$ for minimum temperature drift.

TYPICAL PERFORMANCE

Regulated Output Voltage	5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 50 mA)	1.5 mV

FIGURE 1. Basic Low Voltage Regulator (V_{OUT} = 2 to 7 Volts)



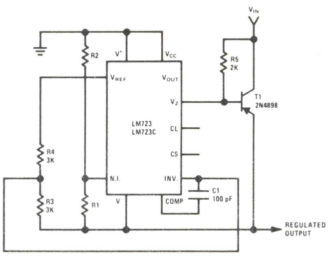
Note: $R3 = \dfrac{R1\,R2}{R1 + R2}$ for minimum temperature drift.

R3 may be eliminated for minimum component count.

TYPICAL PERFORMANCE

Regulated Output Voltage	15V
Line Regulation (ΔV_{IN} = 3V)	1.5 mV
Load Regulation (ΔI_L = 50 mA)	4.5 mV

FIGURE 2. Basic High Voltage Regulator (V_{OUT} = 7 to 37 Volts)

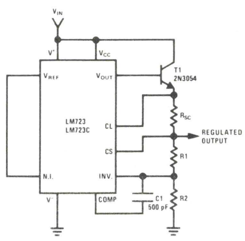


Note 7

TYPICAL PERFORMANCE

Regulated Output Voltage	−15V
Line Regulation (ΔV_{IN} = 3V)	1 mV
Load Regulation (ΔI_L = 100 mA)	2 mV

FIGURE 3. Negative Voltage Regulator

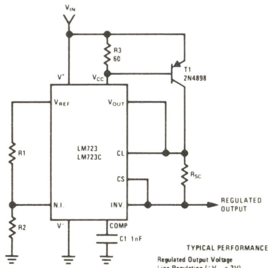


TYPICAL PERFORMANCE

Regulated Output Voltage	+15V
Line Regulation (ΔV_{IN} = 3V)	1.5 mV
Load Regulation (ΔI_L = 1A)	15 mV

FIGURE 4. Positive Voltage Regulator (External NPN Pass Transistor)

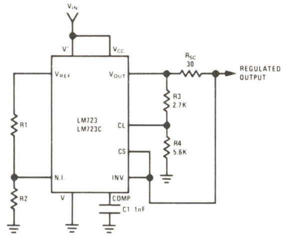
typical applications (con't.)



TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 1A)	5 mV

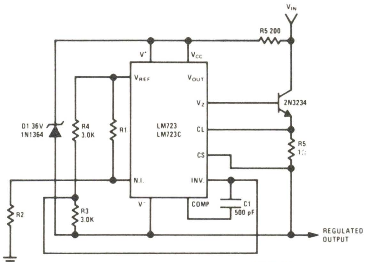
FIGURE 5. Positive Voltage Regulator (External PNP Pass Transistor)



TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 10 mA)	1 mV
Short Circuit Current	20 mA

FIGURE 6. Foldback Current Limiting

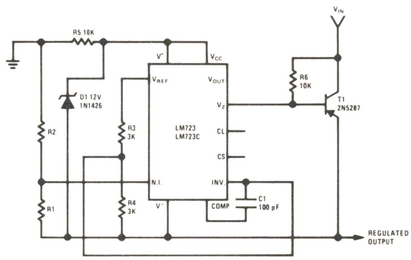


Note 7

TYPICAL PERFORMANCE

Regulated Output Voltage	+50V
Line Regulation (ΔV_{IN} = 20V)	15 mV
Load Regulation (ΔI_L = 50 mA)	20 mV

FIGURE 7. Positive Floating Regulator

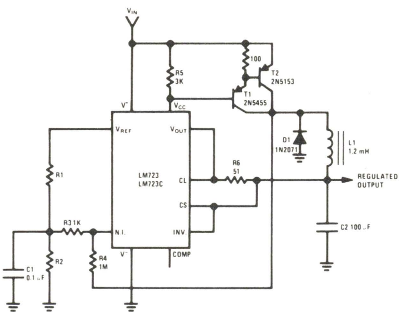


Note 7

TYPICAL PERFORMANCE

Regulated Output Voltage	-100V
Line Regulation (ΔV_{IN} = 20V)	30 mV
Load Regulation (ΔI_L = 100 mA)	20 mV

FIGURE 8. Negative Floating Regulator

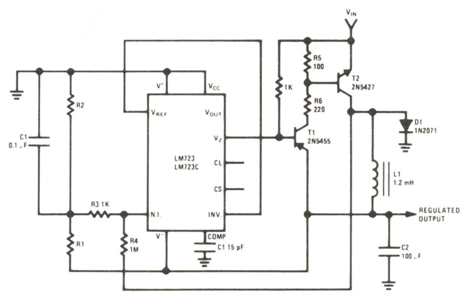


Note 3

TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 30V)	10 mV
Load Regulation (ΔI_L = 2A)	80 mV

FIGURE 9. Positive Switching Regulator

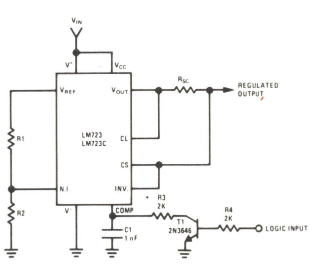


Notes 3, 7

TYPICAL PERFORMANCE

Regulated Output Voltage	-15V
Line Regulation (ΔV_{IN} = 20V)	8 mV
Load Regulation (ΔI_L = 2A)	6 mV

FIGURE 10. Negative Switching Regulator

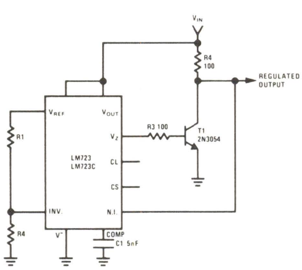


Note: Current limit transistor may be used for shutdown if current limiting is not required.

TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 50 mA)	1.5 mV

FIGURE 11. Remote Shutdown Regulator with Current Limiting



Note 7

TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 10V)	0.5 mV
Load Regulation (ΔI_L = 100 mA)	1.5 mV

FIGURE 12. Shunt Regulator

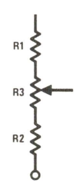


FIGURE 13. Output Voltage Adjust (See Note 5)

Operational Amplifiers

LH0001* low power operational amplifier

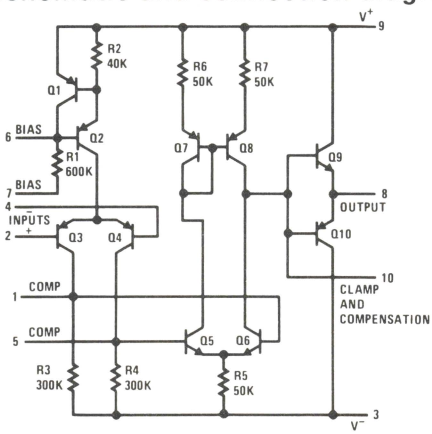
general description

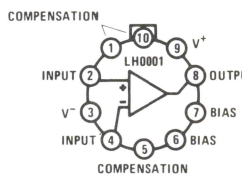
The LH0001 is a general purpose operational amplifier designed for extremely low quiescent power. Typical NO-load dissipation at 25°C is 2 milliwatts at $V_S = \pm 15$ volts, and 0.5 milliwatts at $V_S = \pm 5$ volts. Even with this low power dissipation, the LH0001 will deliver ±10 volts into a 2K load with ±15 volt supplies, and typical short circuit currents of 20 to 30 milliamps. Additional features are:

- Operation from ±5V to ±20V
- Very low offset voltage: typically 200 μV at 25°C, 600 μV at −55°C to 125°C
- Very low input offset current: typically 3 nA at 25°C, 6 nA at −55°C
- Low noise: typically 3 μV rms
- Frequency compensation with 2 small capacitors
- Output may be clamped at any desired level
- Output is continuously short circuit proof

The LH0001 is ideally suited for space borne applications or where battery operated equipment requires extremely low power dissipation.

schematic and connection diagrams





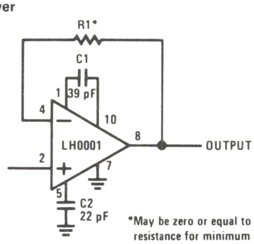
TOP VIEW

Note: Pin 7 must be grounded or connected to a voltage at least 5 volts more negative than the positive supply (Pin 9). Pin 7 may be connected to the negative supply, however the standby current will be increased. A resistor may be inserted in series with Pin 7 up to a maximum of 100 kΩ per volt between Pin 3 and Pin 9.

Order Number LH0001H
See Package 14

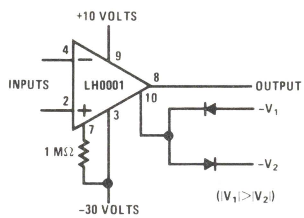
typical applications

Voltage Follower

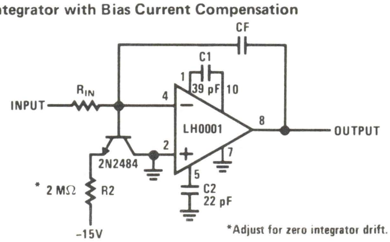


*May be zero or equal to source resistance for minimum offset.

Voltage Comparator for Driving MOS Circuits

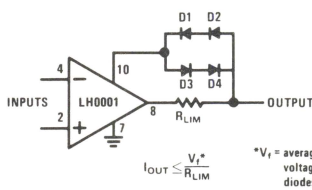


Integrator with Bias Current Compensation



*Adjust for zero integrator drift.

External Current Limiting Method



$I_{OUT} \leq \frac{V_f{}^*}{R_{LIM}}$

*V_f = average forward voltage drop of diodes D1 to D4 at 20 to 50 μA.

*Previously called NH0001

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±7V
Input Voltage	Equal to supply
Short Circuit Duration (Note 1)	Continuous
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering 10 sec.)	300°C

electrical characteristics (Note 2)

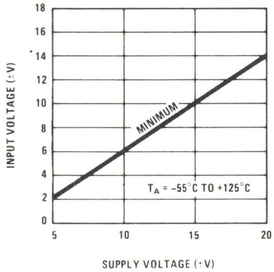
PARAMETER	TEMP (°C)	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	25 −55 to 125	$R_S \le 5K$ $R_S \le 5K$		0.2 0.6	1.0 2.0	mV mV
Input Offset Current	25 to 125 −55				20 100	nA nA
Input Bias Current	25 to 125 −55				100 300	nA nA
Supply Current (+)	25 125 −55	$V_S = \pm 20V$ $V_S = \pm 20V$ $V_S = \pm 20V$		90 70 100	125 100 150	μA μA μA
Supply Current (−)	25 125 −55	$V_S = \pm 20V$ $V_S = \pm 20V$ $V_S = \pm 20V$		60 45 75	90 75 125	μA μA μA
Voltage Gain	−55 to 25 125	R_L = 100 KΩ, $V_S = \pm 15V$, $V_{OUT} = \pm 10V$ R_L = 100 KΩ, $V_S = \pm 15V$, $V_{OUT} = \pm 10V$	25 10	60 30		V/mV V/mV
V_{OUT}	25 −55 125	$V_S = \pm 15V$, R_L = 2K $V_S = \pm 15V$, R_L = 2K $V_S = \pm 15V$, R_L = 2K	10 9 11	11.5 10.5 12.5		V V V
Common Mode Rejection Ratio	−55 to 125	$V_S = \pm 15V$, $V_{IN} = \pm 10V$, $R_S \le 5K$	70	90		dB
Power Supply Rejection Ratio	−55 to 125	$V_S = \pm 15V$, ΔV = 5V to 20V, $R_S = \le 5K$	70	90		dB
Input Resistance	25		0.5	1.5		MΩ
Average Temperature Coefficient of Offset Voltage	−55 to 125	$R_S \le 5K$		4		μV/°C
Average Temperature Coefficient of Bias Current	−55 to 125			0.4		μA/°C
Equivalent Input Noise Voltage	25	R_S = 1K, f = 5 Hz to 1000 Hz, $V_S = \pm 15V$		3.0		μV rms

Note 1: Based on maximum short circuit current of 50 mA, device may be operated at any combination of supply voltages, and temperature to be within rated power dissipation (see Curve).

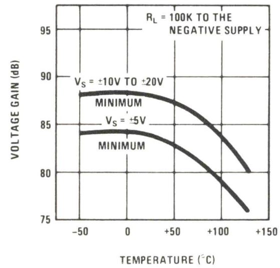
Note 2: These specifications apply for Pin 7 grounded, for $\pm 5V \le V_S \le \pm 20V$, with Capacitor C1 = 39 pF from Pin 1 to Pin 10, and C2 = 22 pF from Pin 5 to ground, unless otherwise specified.

guaranteed performance

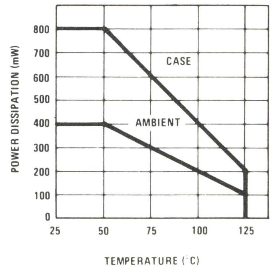
Input Voltage Range



Small Signal Voltage Gain

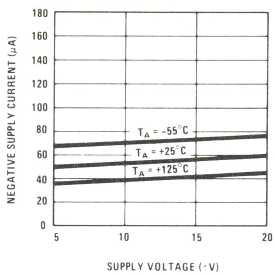


Maximum Power Dissipation

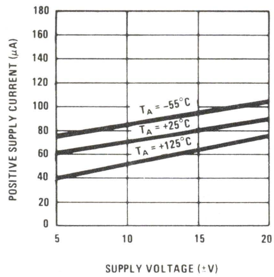


typical performance characteristics

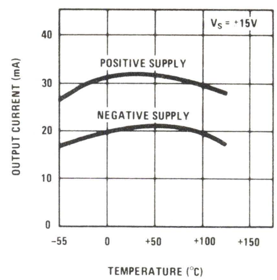
Negative Supply Current



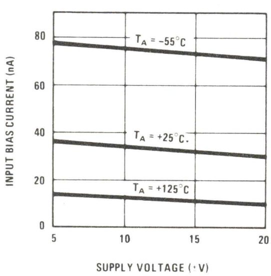
Positive Supply Currents



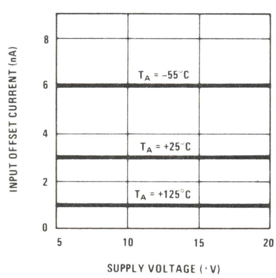
Short Circuit Output Current



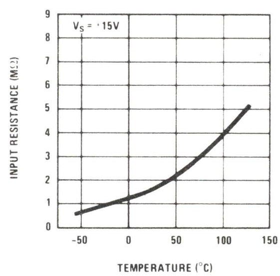
Input Bias Current



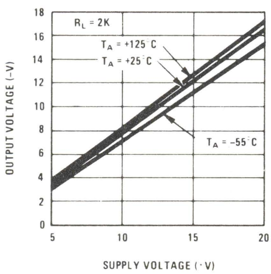
Input Offset Current



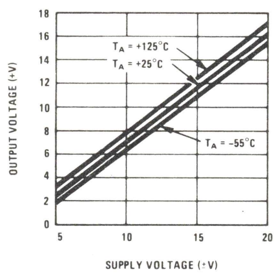
Input Resistance



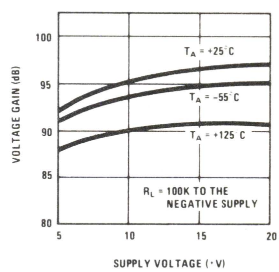
Negative Output Voltage Swing



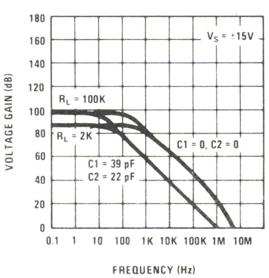
Positive Output Voltage Swing



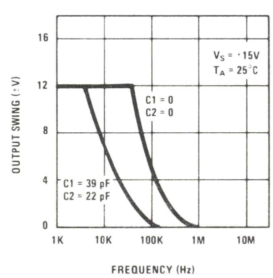
Voltage Gain



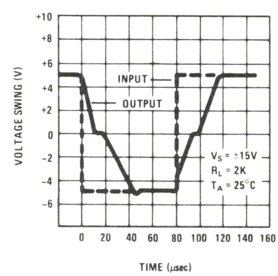
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LH0001A/LH0001AC micropower operational amplifier

general description

The LH0001A/LH0001AC is a micropower, high performance integrated circuit operational amplifier designed to have a no load power dissipation of less than 0.5 mW at $V_S = \pm 5V$ and less than 2 mW at $V_S = \pm 20V$. Open loop gain is greater than 50k and input bias current is typically 20 nA.

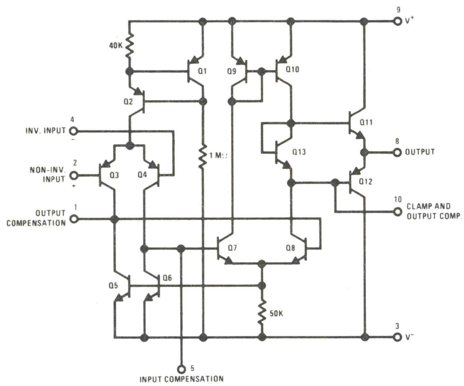
features

- 1.0 mV Typical low offset voltage
- 5 nA Typical low offset current
- 3 μVrms Typical low noise
- Simple frequency compensation
- Moderate bandwidth and slewrate
- Output short circuit proof

The LH0001A/LH0001AC may be substituted directly for the LH0001/LH0001C. Low power consumption, high open loop gain, and excellent input characteristics make the LH0001A an ideal amplifier for many low power applications such as battery powered instrument or transducer amplifiers.

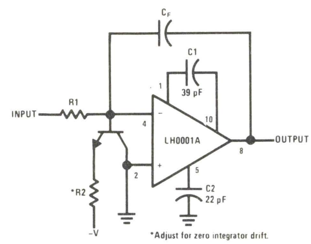
The LH0001A is specified for operation over the –55°C to +125°C military temperature range. The LH0001AC is specified for operation over the 0°C to +85°C temperature range.

schematic diagram*



*Pin shown for TO-5 package

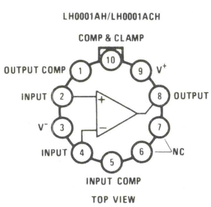
typical application*



Integrator with Bias Compensation

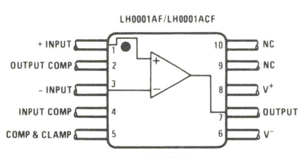
connection diagrams

Metal Can Package



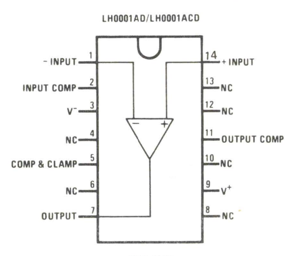
Order Number
LH0001AH or LH0001ACH
See Package 14

Flat Package



Order Number
LH0001AF or LH0001ACF
See Package 3

Cavity Dual-In-Line Package



Order Number
LH0001AD or LH0001ACD
See Package 1

absolute maximum ratings

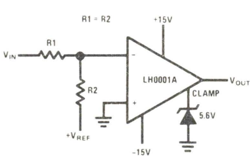
Supply Voltage		±20V
Power Dissipation (See curve)		400 mW
Differential Input Voltage		±7V
Input Voltage		$\pm V_S$
Short Circuit Duration		Continuous
Operating Temperature Range	LH0001A	−55°C to 125°C
	LH0001AC	−25°C to 85°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 1)

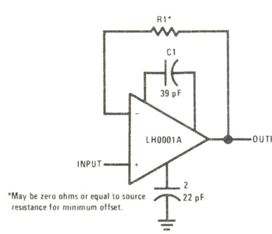
PARAMETERS	CONDITIONS	LH0001A			LH0001AC			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 1k$, $T_A = 25°C$		1.0	2.5		2.0	5.0	mV
				4.0			7.0	mV
Input Bias Current	$T_A = 25°C$		20	100		20	200	nA
				300			300	nA
Input Offset Current	$T_A = 25°C$		5	20		20	60	nA
				100			100	nA
Supply Current	$V_S = \pm 20V$, $T_A = 25°C$		80	125		80	125	µA
	$V_S = \pm 20V$			150			150	nA
Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = 10V$, $R_L = 100k$,	25	60		25	60		V/mV
	$T_A = 25°C$	25	60		25	60		
	$V_S = \pm 15V$, $V_{OUT} = 10V$, $R_L = 100k$	10	30		10			V/mV
Output Voltage	$V_S = \pm 15V$, $R_L = 2k$, $T_A = 25°C$	10	11.5		10	11.5		V
	$V_S = \pm 15V$, $R_L = 2k$	9			9			V
Common Mode Rejection Ratio	$V_S = \pm 15V$, $V_{IN} = 10V$, $R_S = 1k$	70	90		70	90		db
Power Supply Rejection Ratio	$V_S = \pm 15V$, $R_S = 1k$, $V_S = \pm 5V$ to $\pm 20V$	70	90		70	90		db
Equivalent Input Noise Voltage	$V_S = \pm 15V$, $R_S = 1k$, $T_A = 25°C$, f = 500 Hz to 5 kHz		3.0			3.0		µVrms
Average Temperature Coefficient of Offset Voltage	$R_S \leq 1k$		3.0			3.0		µV/°C
Average Temperature Coefficient of Bias Current			0.3			0.3		nA/°C

Note 1: The specifications apply for $\pm 5V \leq V_S \leq 20V$, with output compensation capacitor, C_1 = 39 pF, input compensation capacitor, C_2 = 22 pF, −55°C to 125°C for the LH0001A and −25°C to +85°C for the LH0001AC unless otherwise specified.

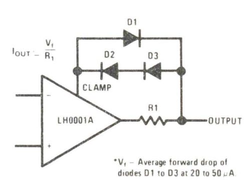
typical applications



TTL/DTL Compatible Comparator



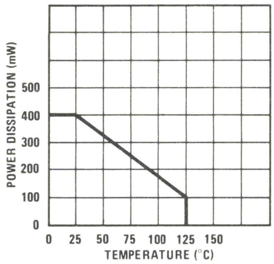
Voltage Follower



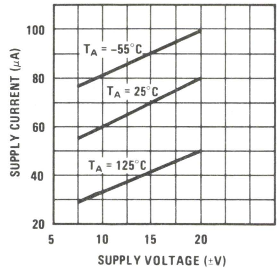
External Output Current Limiting

typical performance characteristics

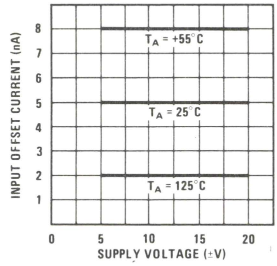
Maximum Power Dissipation



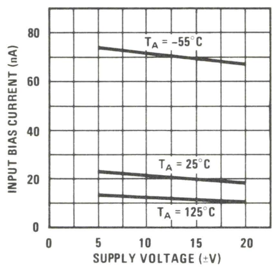
Supply Current



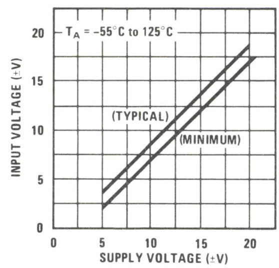
Input Offset Current



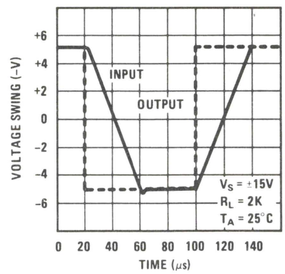
Input Bias Current



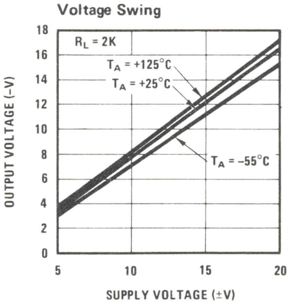
Input Voltage Range



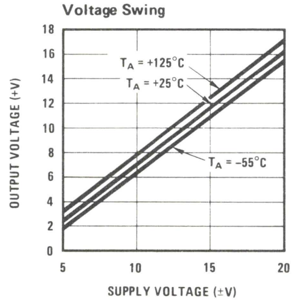
Voltage Follower
Pulse Response



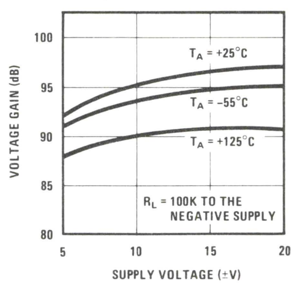
Negative Output
Voltage Swing



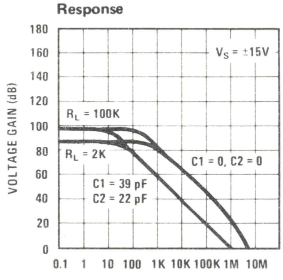
Positive Output
Voltage Swing



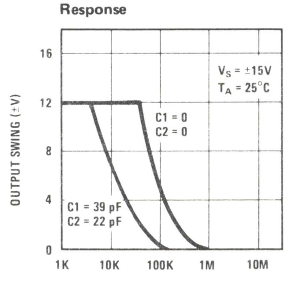
Voltage Gain



Open Loop Frequency
Response



Large Signal Frequency
Response



Operational Amplifiers

LH0002/LH0002C* current amplifier

general description

The LH0002/LH0002C is a general purpose thick film hybrid current amplifier that is built on a single substrate. The circuit features:

- High Input Impedance 400 kΩ
- Low Output Impedance 6Ω
- High Power Efficiency
- Low Harmonic Distortion
- DC to 30 MHz Bandwidth
- Output Voltage Swing that Approaches Supply Voltage
- 400 mA Pulsed Output Current
- Slew rate is typically 200V/μs
- Operation from ±5V to ±20V

These features make it ideal to integrate with an operational amplifier inside a closed loop configuration to increase current output. The symmetrical output portion of the circuit also provides a low output impedance for both the positive and negative slopes of output pulses.

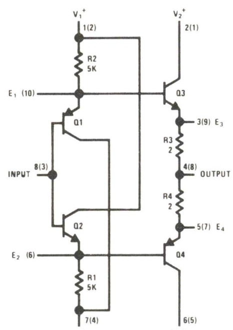
The LH0002 is available in an 8-lead low-profile TO-5 header; the LH0002C is also available in an 8-lead TO-5, and a 10-pin molded dual-in-line package.

The LH0002 is specified for operation over the −55°C to +125°C military temperature range. The LH0002C is specified for operation over the 0°C to +85°C temperature range.

applications

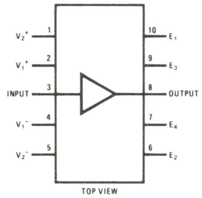
- Line driver
- 30 MHz buffer
- High speed D/A conversion
- Instrumentation buffer
- Precision current source

schematic and connection diagrams



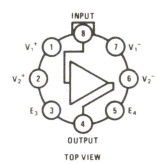
Pin numbers in parentheses denote pin connections for dual-in-line package.

Dual-In-Line Package



Order Number LH0002CN
See Package 21

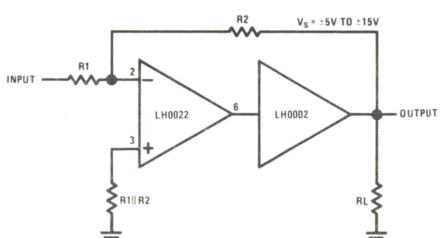
Metal Can Package



Order Number LH0002H or LH0002CH
See Package 11

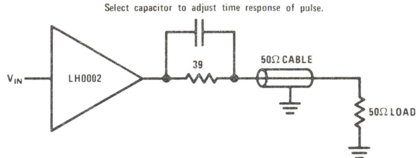
typical applications

High Current Operational Amplifier



Line Driver

Select capacitor to adjust time response of pulse.



*Previously called NH0002/NH0002C

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation Ambient		600 mW
Input Voltage (Equal to Power Supply Voltage)		
Storage Temperature Range		−65°C to +150°C
Operating Temperature Range	LH0002	−55°C to +125°C
	LH0002C	0°C to +85°C
Steady State Output Current		±100 mA
Pulsed Output Current (50 ms On/1 sec Off)		±400 mA

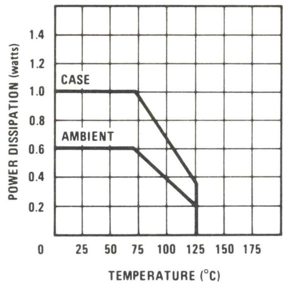
electrical characteristics (Note 1)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Voltage Gain	R_S = 10 kΩ, R_L = 1.0 kΩ V_{IN} = 3.0 V_{PP}, f = 1.0 kHz T_A = −55°C to 125°C	.95	.97		
AC Current Gain	V_{IN} = 1.0 V_{rms} f = 1.0 kHz		40		A/mA
Input Impedance	R_S = 200 kΩ, V_{IN} = 1.0 V_{rms}, f = 1.0 kHz, R_L = 1.0 kΩ	180	400	–	kΩ
Output Impedance	V_{IN} = 1.0 V_{rms}, f = 1.0 kHz R_L = 50Ω, R_S = 10 kΩ	–	6	10	Ω
Output Voltage Swing	R_L = 1.0 kΩ, f = 1.0 kHz	±10	±11	–	V
Output Voltage Swing	V_S = ±15V, V_{IN} = ±10V, R_L = 100Ω , T_A = 25°C	±9.5V			
DC Output Offset Voltage	R_S = 300Ω, R_L = 1.0 kΩ T_A = −55°C to 125°C	–	±10	±30	mV
DC Input Offset Current	R_S = 10 kΩ, R_L = 1.0 kΩ T_A = −55°C to 125°C	–	±6.0	±10	μA
Harmonic Distortion	V_{IN} = 5.0 V_{rms}, f = 1.0 kHz	–	0.1	–	%
Bandwidth	V_{IN} = 1.0 V_{rms}, R_L = 50Ω, f = 1 MHz	30	50	–	MHz
Positive Supply Current	R_S = 10 kΩ, R_L = 1 kΩ	–	+6.0	+10.0	mA
Negative Supply Current	R_S = 10 kΩ, R_L = 1 kΩ	–	−6.0	−10.0	mA

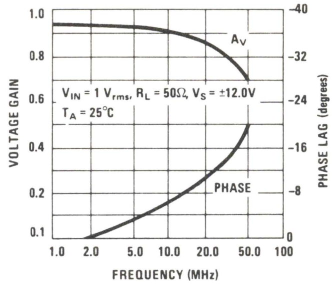
Note 1: Specification applies for T_A = 25°C with +12V on Pins 1 and 2; −12V on Pins 6 and 7 for the metal can package and +12V on Pins 1 and 2; −12V on Pins 4 and 5 for the dual-in-line package unless otherwise specified. The parameter guarantees for LH0002C apply over the temperature range of 0°C to +85°C, while parameters for the LH0002 are guaranteed over the temperature range −55°C to 125°C.

typical performance

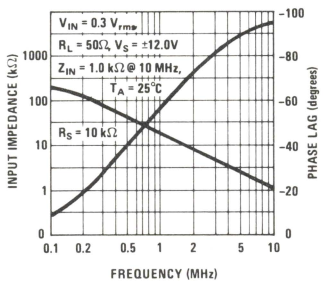
Maximum Power Dissipation



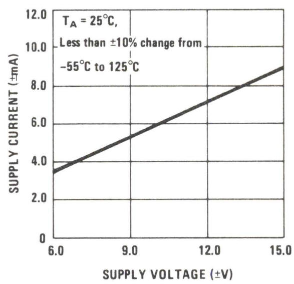
Frequency Response



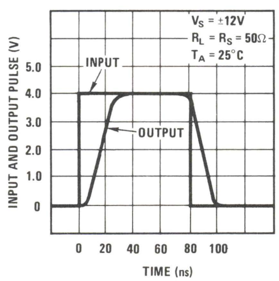
Input Impedance (Magnitude & Phase)



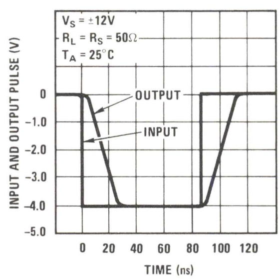
Supply Current



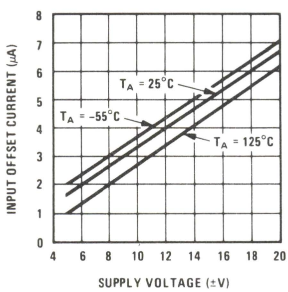
Positive Pulse



Negative Pulse



Input Offset Current



Operational Amplifiers

LH0003/LH0003C* wide bandwidth operational amplifier

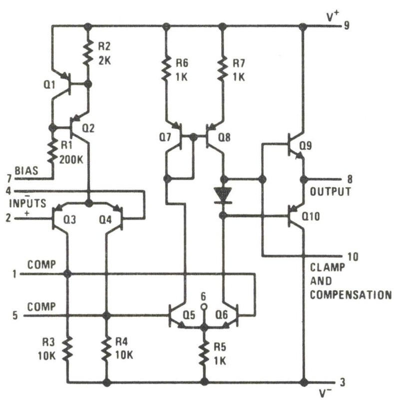
general description

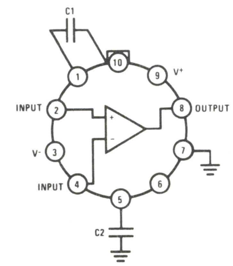
The LH0003/LH0003C is a general purpose operational amplifier which features: slewing rate up to 70 volts/μsec, a gain bandwidth of up to 30 MHz, and high output currents. Other features are:

- Very low offset voltage — Typically 0.4 mV
- Large output swing — > ±10V into 100Ω load
- High CMRR — Typically > 90 dB
- Good large signal frequency response — 50 kHz to 400 kHz depending on compensation

The LH0003 is specified for operation over the –55°C to +125°C military temperature range. The LH0003C is specified for operation over the 0°C to +85°C temperature range.

schematic and connection diagrams





TOP VIEW

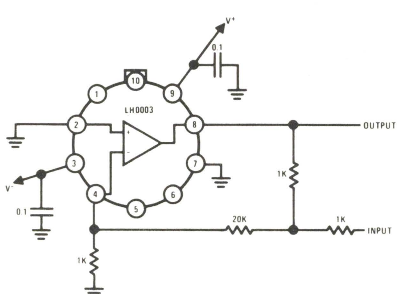
Order Number LH0003H or LH0003CH
See Package 14

Circuit Gain	C_1 pF	C_2 pF	Slew Rate $R_L > 200\Omega$; V/μsec	Full Output Frequency $R_L = 200\Omega$ $V_{OUT} = \pm 10$ V
≥ 40	0	0	70	400 kHz
≥ 10	5	30	30	350 kHz
≥ 5	15	30	15	250 kHz
≥ 2	50	50	5	100 kHz
≥ 1	90	90	2	50 kHz

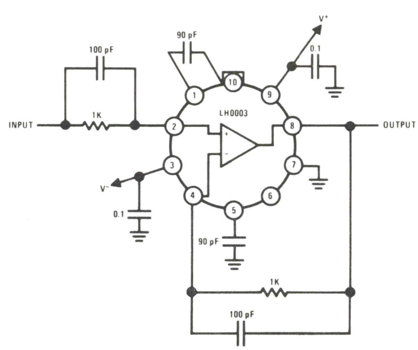
Typical Compensation

typical applications

High Slew Rate Unity Gain Inverting Amplifier



Unity Gain Follower



*Previously called NH0003/NH0003C

absolute maximum ratings

Supply Voltage		±20V
Power Dissipation		See curve
Differential Input Voltage		±7V
Input Voltage		Equal to supply
Load Current		120 mA
Operating Temperature Range	NH0003	−55°C to +125°C
	NH0003C	0°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Notes 1 & 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S < 1k$		0.4	3.0	mV
Input Offset Current			0.02	0.2	μA
Input Bias Current			0.4	2.0	μA
Supply Current	$V_S = \pm 20V$		1.2	3	mA
Voltage Gain	$R_L = 100k$, $V_S = \pm 15V$, $V_{OUT} = \pm 10V$	20	70		V/mV
Voltage Gain	$R_L = 2k$, $V_S = \pm 15V$, $V_{OUT} = \pm 10V$	15	40		V/mV
Output Voltage Swing	$V_S = \pm 15$, $R_L = 100\Omega$	±10	±12		V
Input Resistance			100		kΩ
Average Temperature Coefficient of Offset Voltage	$R_S < 5k$		4		μV/°C
Average Temperature Coefficient of Bias Current			8		nA/°C
CMRR	$R_S < 1k$, $V_S = \pm V$, $V_{IN} = \pm 10V$	70	90		dB
PSRR	$R_S < 1k$, $V_S = \pm 15V$, $\Delta V = 5V$ to $20V$	70	90		dB
Equivalent Input Noise Voltage	$R_S = 1K$, f = 10 kHz to 100 kHz, $V_S = \pm 15V$ dc		1.8		μVrms

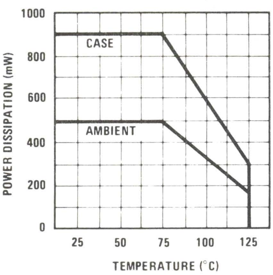
Note 1. These specifications apply for Pin 7 grounded, for $\pm 5V < V_S < \pm 20V$, with capacitor $C_1 = 90$ pF from Pin 1 to Pin 10 and $C_2 = 90$ pF from Pin 5 to ground, over the specified operating temperature range, unless otherwise specified.

Note 2. Typical values are for $t_{AMBIENT} = 25°C$ unless otherwise specified.

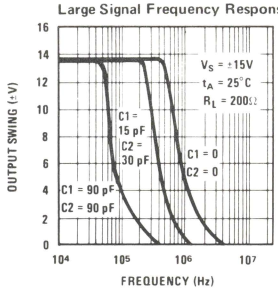
2

typical performance

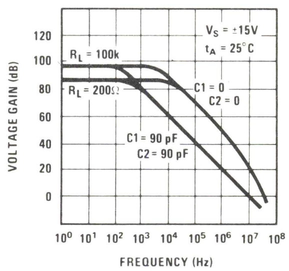
Maximum Power Dissipation



Large Signal Frequency Response



Open Loop Frequency Response



Operational Amplifiers

LH0004/LH0004C* high voltage operational amplifier

general description

The LH0004/LH0004C is a general purpose operational amplifier designed to operate from supply voltages up to ±40V. The device dissipates extremely low quiescent power, typically 8 mW at 25°C and V_S = ±40V. Additional features include:

- Capable of operation over the range of ±5V to ±40V.
- Large output voltage typically ±35V for the LH0004 and ±33V for the LH0004C into a 2 KΩ load with ±40V supplies
- Low input offset current typically 20 nA for the LH0004 and 45 nA for the LH0004C
- Low input offset voltage typically 0.3 mV
- Frequency compensation with two small capacitors.
- Low power consumption 8 mW at ±40V

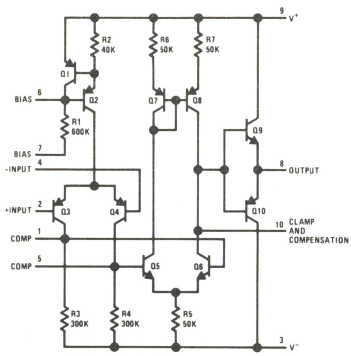
The LH0004's high gain and wide range of operating voltages make it ideal for applications requiring large output swing and low power dissipation.

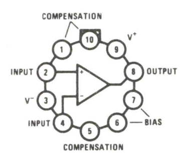
The LH0004 is specified for operation over the −55°C to +125°C military temperature range. The LH0004C is specified for operation over the 0°C to +85°C temperature range.

applications

- Precision high voltage power supply.
- Resolver excitation.
- Wideband high voltage amplifier.
- Transducer power supply.

schematic and connection diagrams





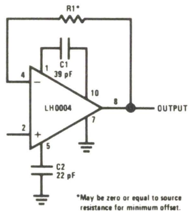
TOP VIEW

Note: Pin 7 must be grounded or connected to a voltage at least 5 volts more negative than the positive supply (Pin 9). Pin 7 may be connected to the negative supply; however, the standby current will be increased. A resistor may be inserted in series with Pin 7 to Pin 9. The value of the resistor should be a maximum of 100 KΩ per volt of potential between Pin 3 and Pin 9.

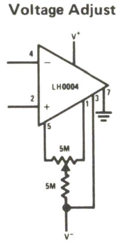
Order Number LH0004H or LH0004CH
See Package 14

typical applications

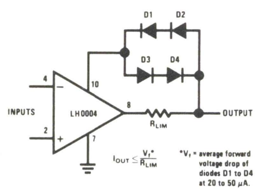
Voltage Follower



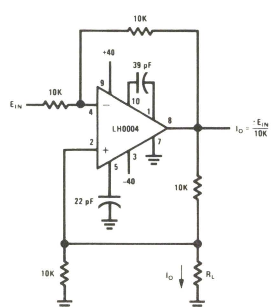
Input Offset Voltage Adjust



External Current Limiting Method



High Compliance Current Source



*Previously called NH0004/NH0004C

absolute maximum ratings

Supply Voltage, Continuous	±45V
Supply Voltage, Transient (≤0.1 sec, no load)	±60V
Power Dissipation (See curve)	400 mW
Differential Input Voltage	±7V
Input Voltage	Equal to supply
Short Circuit Duration	3 sec
Operating Temperature Range LH0004	−55°C to +125°C
LH0004C	0°C to 85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

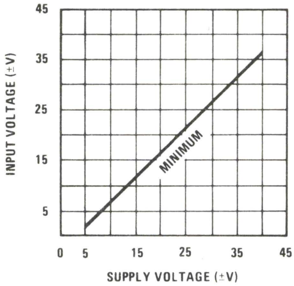
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0004			LH0004C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 5k$, $T_A = 25°C$		0.3	1.0		0.3	1.5	mV
	$R_S \leq 5k$			2.0			3.0	mV
Input Bias Current	$T_A = 25°C$		20	100		30	120	nA
	$= -55°C$			300			300	nA
Input Offset Current	$T_A = 25°C$		3	20		10	45	nA
	$= -55°C$			100			150	nA
Positive Supply Current	$V_S = \pm 40V$, $T_A = 25°C$		110	150		110	150	μA
	$V_S = \pm 40V$			175			175	μA
Negative Supply Current	$V_S = \pm 40V$, $T_A = 25°C$		80	100		80	100	μA
	$V_S = \pm 40V$			135			135	μA
Voltage Gain	$V_S = \pm 40V$, $R_L = 100k$, $T_A = 25°C$ $V_{OUT} = \pm 30V$	30	60		30	60		V/mV
	$V_S = \pm 40V$, $R_L = 100k$ $V_{OUT} = \pm 30V$	10			10			V/mV
Output Voltage	$V_S = \pm 40V$, $R_L = 2k$	±30	±35		±30	±33		V
	$V_S = \pm 40V$, $R_L = 4k$	±34	±36		±33	±35		V
CMRR	$V_S = \pm 40V$, $R_S \leq 5k$ $V_{IN} = \pm 33V$	70	90		70	90		dB
PSRR	$V_S = \pm 40V$, $R_S \leq 5k$ $\Delta V = 20V$ to $40V$	70	90		70	90		dB
Average Temperature Coefficient Offset Voltage	$R_S \leq 5k$		4.0			4.0		μV/°C
Average Temperature Coefficient of Offset Current			0.4			0.4		μA/°C
Equivalent Input Noise Voltage	$R_S = 1k$, $V_S = \pm 40V$ f = 500 Hz to 5 kHz, $T_A = 25°C$		3.0			3.0		μVrms

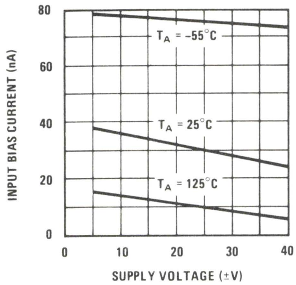
Note 1: These specifications apply for $\pm 5V \leq V_S \leq \pm 40V$, Pin 7 grounded, with capacitors C1 = 39 pF between Pin 1 and Pin 10, C2 = 22 pF between Pin 5 and ground, −55°C to 125°C for the LH0004, and 0°C to 85°C for the LH0004C unless otherwise specified.

typical performance

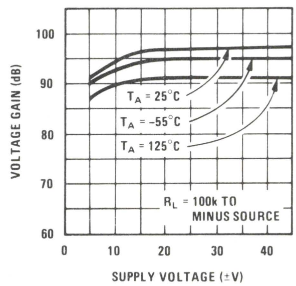
Input Voltage Range



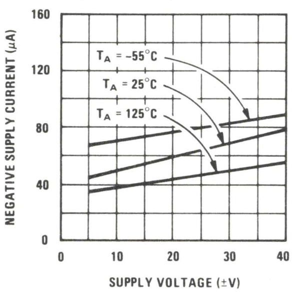
Input Bias Current



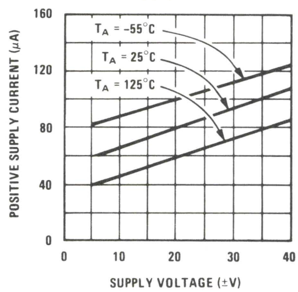
Voltage Gain



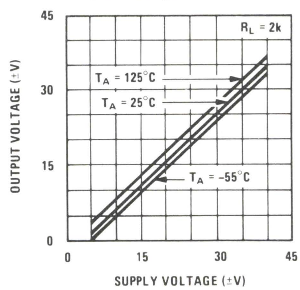
Negative Supply Current



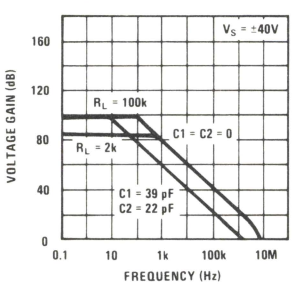
Positive Supply Current



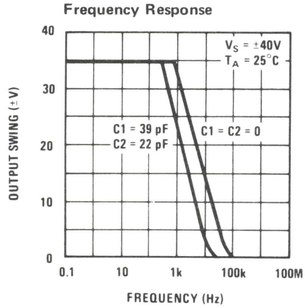
Output Voltage



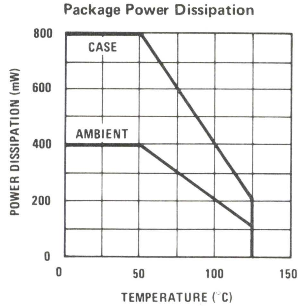
Open Loop Frequency Response



Large Signal Frequency Response



Package Power Dissipation



Operational Amplifiers

LH0005/LH0005A* operational amplifier

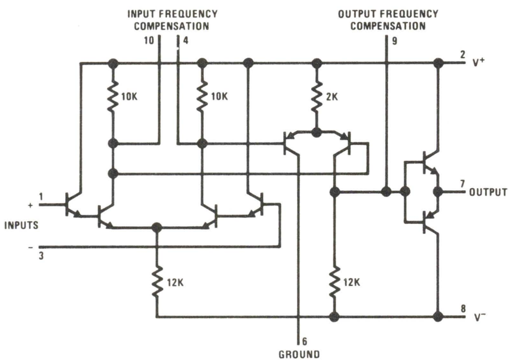
general description

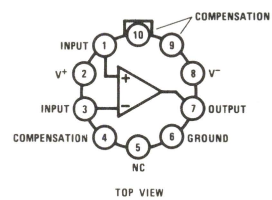
The LH0005/LH0005A is a hybrid integrated circuit operational amplifier employing thick film resistors and discrete silicon semiconductors in its design. The select matching of the input pairs of transistors results in low input bias currents and a very low input offset current, both of which exhibit excellent temperature tracking. In addition, the device features:

- Very high output current capability: ±50 mA into a 100 ohm load
- Low standby power dissipation: typically 60 mW at ±12V
- High input resistance: typically 2M at 25°C
- Full operating range: −55°C to +125°C
- Good high frequency response: unity gain at 30 MHz

With no external roll-off network, the amplifier is stable with a feedback ratio of 10 or greater. By adding a 200 pF capacitor between pins 9 and 10, and a 200 ohm resistor in series with a 75 pF capacitor from pin 4 to ground, the amplifier is stable to unity gain. The unity gain loop phase margin with the above compensation is typically 70 degrees. With a gain of 10 and no compensation the loop phase margin is typically 50 degrees.

schematic and connection diagrams

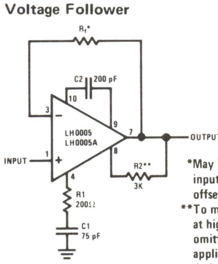




Order Number LH0005H or LH0005AH
See Package 14

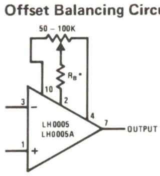
typical applications

Voltage Follower



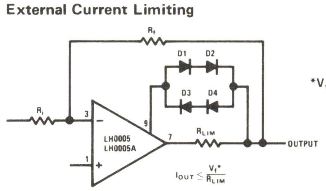
*May be zero or equal to the input resistance for minimum offset.
**To minimize crossover distortion at higher frequencies. May be omitted for low frequency application or selected to suit design requirements

Offset Balancing Circuit



*Typical value, R_B = 100K. R_B may be increased for greater sensitivity with reduction in range.

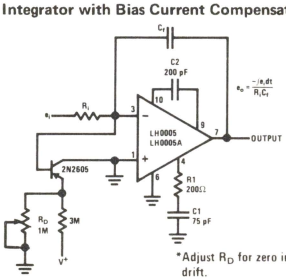
External Current Limiting



*V_f = Average forward voltage drop of diodes D_1 to D_4 at approx. 1 mA.

For continuous short circuit protection (V_S = ±12V, −55°C < T_A < +100°C) R_{LIM} > 50Ω

Integrator with Bias Current Compensation



*Adjust R_D for zero integration drift.

*Previously called NH0005/NH0005A

absolute maximum ratings

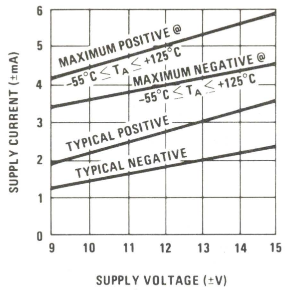
Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±15V
Input Voltage	Equal to supply voltages
Peak Load Current	±100 mA
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

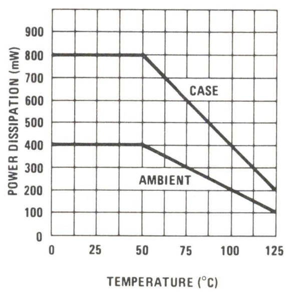
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0005 MIN	LH0005 TYP	LH0005 MAX	LH0005A MIN	LH0005A TYP	LH0005A MAX	UNITS
Input Offset Voltage								
25°C	$R_S \leq 20\ k\Omega$		5	10		1	3	mV
−55°C, 125°C	$R_S \leq 20\ k\Omega$			10			4	mV
Input Offset Current								
25°C to 125°C			10	20		2	5	nA
−55°C			25	75		10	25	nA
Input Bias Current								
25°C to 125°C			15	50		8	25	nA
−55°C			100	250		60	125	nA
Large Signal Voltage Gain								
−55°C to 25°C	R_L = 10K, R2 = 3K, V_{OUT} = ±5V	2	4		4	5.5		V/mV
125°C		1.5	3		3	5		V/mV
Output Voltage Swing								
−55°C to 125°C	$R_L = 10\ k\Omega$	−10		+6	−10		+6	V
25°C to 125°C	$R_L = 100\Omega$	−5		+5	−5		+5	V
−55°C	$R_L = 100\Omega$	−4		+4	−4		+4	V
Input Resistance								
25°C		1	2		1	2		MΩ
Common Mode Rejection Ratio								
25°C	V_{IN} = ±4V, RS $\leq 20\ k\Omega$	55	60		60	66		dB
Power Supply Rejection Ratio								
25°C		55	60		60	66		dB
Supply Current (+)								
−55°C to 125°C			3	5		3	5	mA
Supply Current (−)								
−55°C to 125°C			2	4		2	4	mA
Average Temperature Coefficient of Input Offset Voltage								
−55°C to 125°C	$R_S \leq 20\ k\Omega$		20			10		uV/°C
Output Resistance								
25°C			70			70		Ω

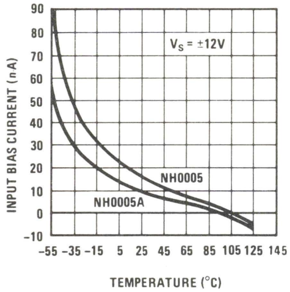
Note 1: These specifications apply for pin 6 grounded, V_S = ±12V, with Resistor $R_1 = 200\Omega$ in series with Capacitor C_1 = 75 pF from pin 4 to ground, and C_2 = 200 pF between pins 9 and 10 unless otherwise specified.

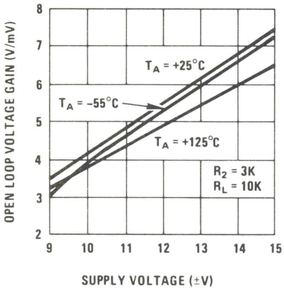
guaranteed performance characteristics

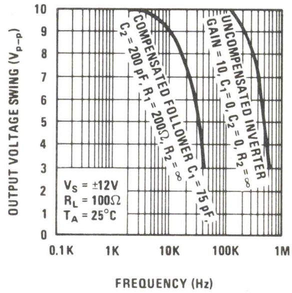


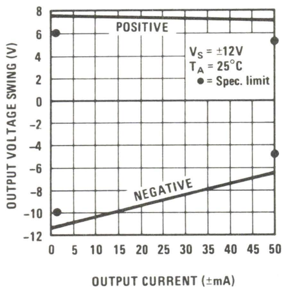


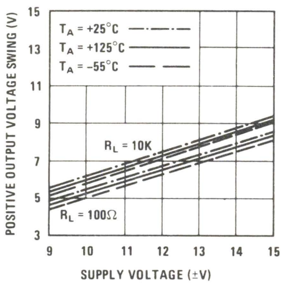
typical performance characteristics

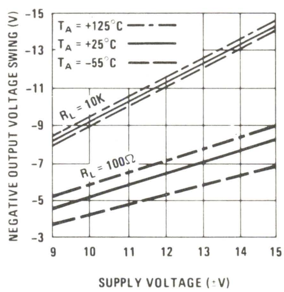


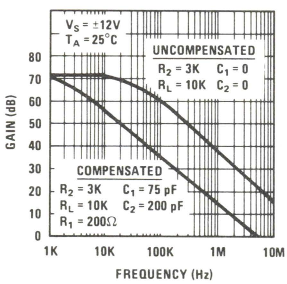


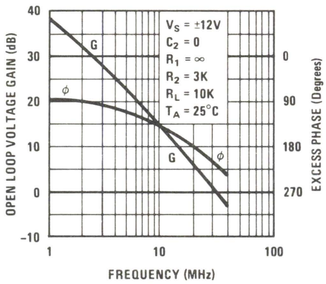


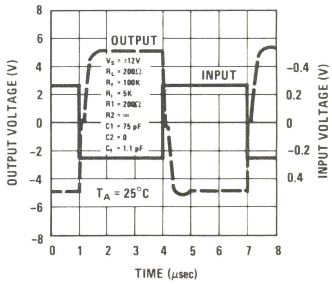












Operational Amplifiers

LH0005C* operational amplifier

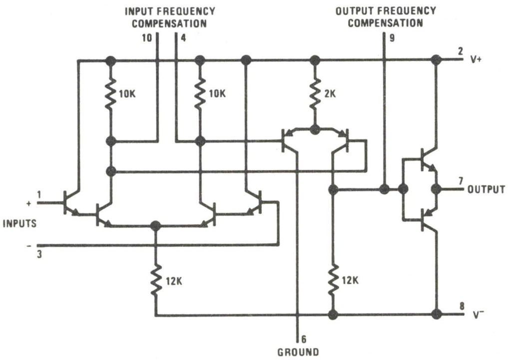
general description

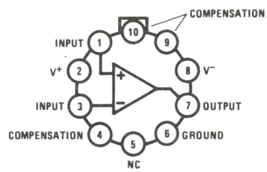
The LH0005C is a hybrid integrated circuit operational amplifier employing thick film resistors and discrete silicon semiconductors in its design. The select matching of the input pairs of transistors results in low input bias currents and a very low input offset current both of which exhibit excellent temperature tracking. In addition, the device features:

- Very high output current capability: ±40 mA into a 100 ohm load
- Low standby power dissipation: typically 60 mW at ±12V
- High input resistance: typically 2M at 25°C
- Operating range: 0° to 70°C
- Good high frequency response: unity gain at 30 MHz

With no external roll-off network, the amplifier is stable with a feedback ratio of 10 or greater. By adding a 200 pF capacitor between pins 9 and 10, and a 200 ohm resistor in series with a 75 pF capacitor from pin 4 to ground, the amplifier is stable to unity gain. The unity gain loop phase margin with the above compensation is typically 70 degrees. With a gain of 10 and no compensation the loop phase margin is typically 50 degrees.

schematic and connection diagrams



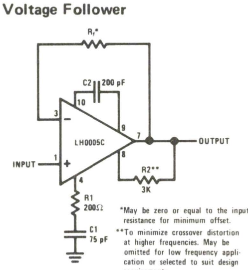


TOP VIEW

Order Number LH0005CH
See Package 14

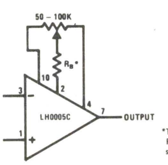
typical applications

Voltage Follower



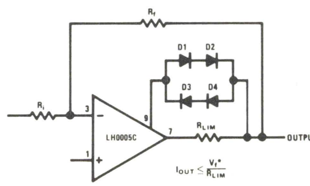
*May be zero or equal to the input resistance for minimum offset.
**To minimize crossover distortion at higher frequencies. May be omitted for low frequency application or selected to suit design requirements.

Offset Balancing Circuit



*Typical value, R_B = 100K, R_B may be increased for greater sensitivity with reduction in range.

External Current Limiting

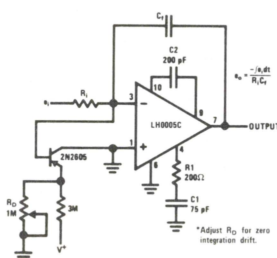


$I_{OUT} \leq \frac{V_f^*}{R_{LIM}}$

For continuous short circuit protection ($V_S = \pm 12V$, $0°C \leq T_A \leq 70°C$, $R_{LIM} \geq 50\Omega$)

*V_f = Average forward voltage drop of diodes D_1 to D_4 at approx. 1 mA

Integrator With Bias Current Compensation



$e_o = \frac{-\int e_i dt}{R_i C_f}$

*Adjust R_D for zero integration drift.

*Previously called NH0005C

absolute maximum ratings

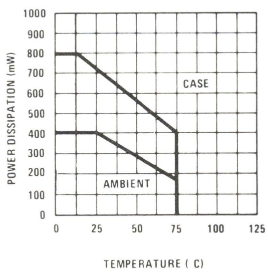
Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±15V
Input Voltage	Equal to supply voltages
Peak Load Current	±100 mA
Storage Temperature Range	−55°C to +125°C
Operating Temperature Range	0°C to 85°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics

PARAMETER	CONDITIONS	LH0005C MIN	LH0005C TYP (Note 2)	LH0005C MAX	UNITS
Input Offset Voltage	$R_S \leq 20\ k\Omega$		3	10	mV
Input Offset Current			5	25	nA
Input Bias Current			20	100	nA
Large Signal Voltage Gain	$R_L = 10K$, $R2 = 3K$, $V_{OUT} = \pm 5V$	2	5		V/mV
Output Voltage Swing	$R_L = 10\ k\Omega$	−10		+6	V
	$R_L = 100\Omega$	−4	±6	+4	V
Input Resistance	$T_A = 25°C$	0.5	2		MΩ
Common Mode Rejection Ratio	$V_{IN} = \pm 4V$, $R_S \leq 20\ k\Omega$, $T_A = 25°C$	50	60		dB
Power Supply Rejection Ratio	$T_A = 25°C$	50	60		dB
Supply Current (+)			3	5	mA
Supply Current (−)			2	4	mA

Note 1: These specifications apply for pin 6 grounded, $V_S = \pm 12V$, with Resistor R1 = 200Ω in series with Capacitor C1 = 75 pF from pin 4 to ground, and C2 = 200 pF between pins 9 and 10, over the temperature range of 0°C to +85°C unless otherwise specified.

Note 2: Typical values are for 25°C only.



Maximum Power Dissipation

2

Operational Amplifiers

LH0020/LH0020C* high gain instrumentation operational amplifier

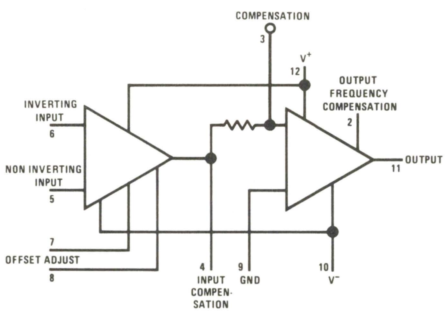
general description

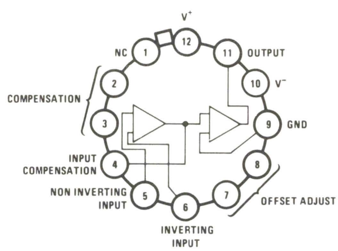
The LH0020/LH0020C is a general purpose operational amplifier designed to source and sink 50 mA output currents. In addition to its high output capability, the LH0020/LH0020C exhibits excellent open loop gain, typically in excess of 100 dB. The parameters of the LH0020 are guaranteed over the temperature range of $-55^{\circ}C$ to $+125^{\circ}C$ and $\pm 15V \leq V_S \leq \pm 22V$, while those of the LH0020C are guaranteed over the temperature range of $0^{\circ}C$ to $85^{\circ}C$ and $\leq \pm 5V \leq V_S \leq \pm 18V$. Additional features include:

- Low offset voltage typically 1.0 mV at 25°C over the entire common mode voltage range.
- Low offset current typically 10 nA at 25°C for the LH0020 and 30 nA for the LH0020C.
- Offset voltage is adjustable to zero with a single potentiometer.
- ±14V, 50 mA output capability.

Output current capability, excellent input characteristics, and large open loop gain make the LH0020/LH0020C suitable for application in a wide variety of applications from precision dc power supplies to precision medium power comparator.

schematic and connection diagrams



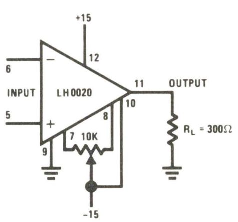


TOP VIEW

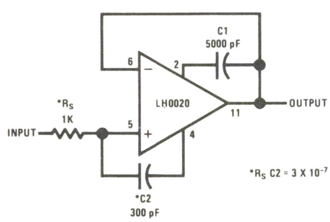
Order Number LH0020G or LH0020CG
See Package 6

typical applications

Offset Adjustment



Unity Gain Frequency Compensation



*Previously called NH0020/NH0020C

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation		1.5W
Differential Input Voltage		±30V
Input Voltage (Note 1)		±15V
Output Short Circuit Duration		Continuous
Operating Temperature Range	LH0020	−55°C to +125°C
	LH0020C	0°C to 85°C
Storage Temperature		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics

PARAMETER	CONDITIONS	LH0020				LH0020C				UNITS
		TEMP °C	MIN	TYP	MAX	TEMP °C	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10k$	25		1.0	2.5	25		1.0	6.0	mV
		−55 to +125		2.0	4.0	0 to 85		3.0	7.5	mV
Input Offset Current		25		10	50	25		30	200	nA
		−55 to +125			100	0 to 85			300	nA
Input Bias Current		25		60	250	25		200	500	nA
		−55 to +125			500	0 to 85			800	nA
Supply Current	$V_S = \pm15V$	25		3.5	5.0	25		3.6	6.0	mA
Input Resistance		25	0.6	1.0		25	0.3	1.0		MΩ
Large Signal Voltage Gain	$V_S = \pm15V$, $R_L = 300\Omega$, $V_O = \pm10V$	25	100	300		25	50	150		V/mV
	$V_S = \pm15V$, $R_L = 300\Omega$, $V_O = \pm10V$	−55 to +125	50			0 to 85	30			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 300\Omega$	25	14.2	14.5		25	14.0	14.2		V
		−55 to +125	14.0			0 to 85	13.5			V
Output Short Circuit Current	$V_S = \pm15V$, $R_L = 0\Omega$	25		100	130	25	25	120	140	mA
Input Voltage Range	$V_S = \pm15V$	−55 to +125	±12			0 to 85	±12			V
										V
Common Mode Rejection Ratio	$R_S \leq 10k$	−55 to +125	90	96		0 to 85	90	96		dB
Power Supply Rejection Ratio	$R_S \leq 10k$	−55 to +125	90	96		0 to 85	90	96		dB

Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 2: These specifications apply for $\pm5V \leq V_S \leq \pm22V$ for the LH0020, $\pm5V \leq V_S \leq \pm18V$ for the LH0020C, pin 9 grounded, and a 5000 pF capacitor between pins 2 and 3, unless otherwise specified.

2

Operational Amplifiers

LH0021/LH0021C 1.0 amp power operational amplifier
LH0041/LH0041C 0.2 amp power operational amplifier

general description

The LH0021/LH0021C and LH0041/LH0041C are general purpose operational amplifiers capable of delivering large output currents not usually associated with conventional IC Op Amps. The LH0021 will provide output currents in excess of one ampere at voltage levels of ±12V; the LH0041 delivers currents of 200 mA at voltage levels closely approaching the available power supplies. In addition, both the inputs and outputs are protected against overload. The devices are compensated with a single external capacitor and are free of any unusual oscillation or latch-up problems.

features

- Output current — 1.0 Amp (LH0021); 0.2 Amp (LH0041)
- Output voltage swing — ±12V into 10Ω (LH0021); ±14V into 100Ω (LH0041)
- Wide full power bandwidth — 15 kHz
- Low standby power — 100 mW at ±15V
- Low input offset voltage and current — 1 mV and 20 nA
- High slew rate — 3.0V/μs
- High open loop gain — 100 dB

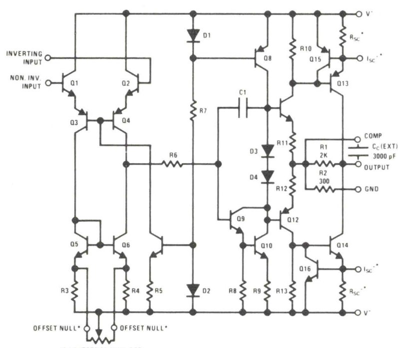
The excellent input characteristics and high output capability of the LH0021 make it an ideal choice for power applications such as DC servos, capstan drivers, deflection yoke drivers, and programmable power supplies.

The LH0041 is particularly suited for applications such as torque driver for internal guidance systems, diddle yoke driver for alpha-numeric CRT displays, cable drivers, and programmable power supplies for automatic test equipment.

The LH0021 is supplied in a 8 pin TO-3 package rated at 20 watts with suitable heatsink. The LH0041 is supplied in both 12 pin TO-8 (2.5 watts with clip on heatsink) and a power 8 pin ceramic DIP (2 watts with suitable heatsink). The LH0021 and LH0041 are guaranteed over the temperature range of −55°C to +125°C while the LH0021C and LH0041C are guaranteed from −25°C to +85°C

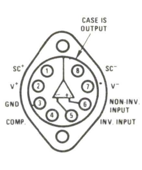
For information on other National op amps, see listing on last page.

schematic and connection diagrams



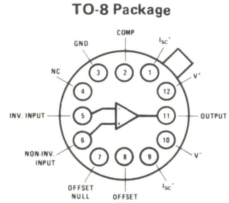
*R_{SC} external on TO-8 and TO-3 packages. R_{SC} internal on "J" package.
Offset Null connections available only on TO-8 "G" package.

TO-3 Package



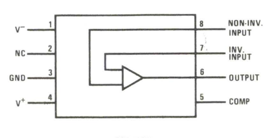
Order Number
LH0021K or LH0021CK
See Package 19

TO-8 Package



Order Number
LH0041G or LH0041CG
See Package 6

Ceramic DIP



Order Number
LH0041CJ
See Package 15

absolute maximum ratings

Supply Voltage		±18V
Power Dissipation		See curves
Differential Input Voltage		±30V
Input Voltage (Note 1)		±15V
Peak Output Current (Note 2)	LH0021/LH0021C	2.0 Amps
	LH0041/LH0041C	0.5 Amps
Output Short Circuit Duration (Note 3)		Continuous
Operating Temperature Range	LH0021/LH0041	−55°C to +125°C
	LH0021C/LH0041C	−25°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

dc electrical characteristics for LH0021/LH0021C (Note 4)

PARAMETER	CONDITIONS	LIMITS LH0021 MIN	LH0021 TYP	LH0021 MAX	LH0021C MIN	LH0021C TYP	LH0021C MAX	UNITS
Input Offset Voltage	$R_S \leq 10\ k\Omega$, $T_C = 25^\circ C$ $R_S \leq 10\ k\Omega$		1.0	3.0 5.0		3.0	6.0 7.5	mV mV
Voltage Drift with Temperature	$R_S \leq 10\ k\Omega$		3	25		5	30	μV/°C
Offset Voltage Drift with Time			5			5		μV/week
Offset Voltage Change with Output Power			5	15		5	20	μV/watt
Input Offset Current	$T_C = 25^\circ C$		30	100 300		50	200 500	nA nA
Offset Current Drift with Temperature			0.1	1.0		0.2	1.0	nA/°C
Offset Current Drift with Time			2			2		nA/week
Input Bias Current	$T_C = 25^\circ C$		100	300 1.0		200	500 1.0	nA μA
Input Resistance	$T_C = 25^\circ C$	0.3	1.0		0.3	1.0		MΩ
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$, $\Delta V_{CM} = \pm 10V$	70	90		70	90		dB
Input Voltage Range	$V_S = \pm 15V$	±12			±12			V
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$, $\Delta V_S = \pm 10V$	80	96		70	90		dB
Voltage Gain	$V_S = \pm 15V$, $V_O = \pm 10V$ $R_L = 1\ k\Omega$, $T_C = 25^\circ C$,	100	200		100	200		V/mV
	$V_S = \pm 15V$, $V_O = \pm 10V$ $R_L = 100\Omega$,	25			20			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 100\Omega$ $V_S = \pm 15V$, $R_L = 10\Omega$	±13.5 ±11.0	14 ±12		±13 ±10	±14 ±12		V V
Output Short Circuit Current	$V_S = \pm 15V$, $T_C = 25^\circ C$, $R_{SC} = 0.5\Omega$	0.8	1.2	1.6	0.8	1.2	1.6	Amps
Power Supply Current	$V_S = \pm 15V$, $V_{OUT} = 0$		2.5	3.5		3.0	4.0	mA
Power Consumption	$V_S = \pm 15V$, $V_{OUT} = 0$		75	105		90	120	mW

ac electrical characteristics for LH0021/LH0021C ($T_A = 25^\circ C$, $V_S = \pm 15V$, $C_C = 3000\ pF$)

PARAMETER	CONDITIONS	LH0021 MIN	LH0021 TYP	LH0021 MAX	LH0021C MIN	LH0021C TYP	LH0021C MAX	UNITS
Slew Rate	$A_V = +1$, $R_L = 100\Omega$	1.5	3.0		1.0	3.0		V/μs
Power Bandwidth	$R_L = 100\Omega$		40			40		kHz
Small Signal Transient Response			0.3	1.0		0.3	1.5	μs
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{IN} = 10V$, $A_V = +1$		4			4		μs
Overload Recovery Time			3			3		μs
Harmonic Distortion	$f = 1\ kHz$, $P_O = 0.5W$		0.2			0.2		%
Input Noise Voltage	$R_S = 50\Omega$, B.W. = 10 Hz to 10 kHz		5			5		μV/rms
Input Noise Current	B.W. = 10 Hz to 10 kHz		0.05			0.05		nA/rms

dc electrical characteristics for LH0041/LH0041C (Note 4)

PARAMETER	CONDITIONS	LIMITS LH0041 MIN	LH0041 TYP	LH0041 MAX	LH0041C MIN	LH0041C TYP	LH0041C MAX	UNITS
Input Offset Voltage	$R_S \leq 10\ k\Omega$, $T_A = 25^\circ C$		1.0	3.0		3.0	6.0	mV
	$R_S \leq 10\ k\Omega$			5.0			7.5	mV
Voltage Drift with Temperature	$R_S \leq 10\ k\Omega$		3			5		$\mu V/^\circ C$
Offset Voltage Drift with Time			5			5		μV/week
Offset Voltage Change with Output Power			15			15		μV/watt
Offset Voltage Adjustment Range	(Note 5)		20			20		mV
Input Offset Current	$T_A = 25^\circ C$		30	100		50	200	nA
				300			500	nA
Offset Current Drift with Temperature			0.1	1.0		0.2	1.0	$nA/^\circ C$
Offset Current Drift with Time			2			2		nA/week
Input Bias Current	$T_A = 25^\circ C$		100	300		200	500	nA
				1.0			1.0	μA
Input Resistance	$T_A = 25^\circ C$	0.3	1.0		0.3	1.0		$M\Omega$
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$, $\Delta V_{CM} = \pm 10V$	70	90		70	90		dB
Input Voltage Range	$V_S = \pm 15V$	±12			±12			V
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$, $\Delta V_S = \pm 10V$	80	96		70	90		dB
Voltage Gain	$V_S = \pm 15V$, $V_O = \pm 10V$ $R_L = 1\ k\Omega$, $T_A = 25^\circ C$	100	200		100	200		V/mV
	$V_S = \pm 15V$, $V_O = \pm 10V$ $R_L = 100\Omega$	25			20			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 100\Omega$	±13.0	14.0		±13.0	±14.0		V
Output Short Circuit Current	$V_S = \pm 15V$, T_A · $25^\circ C$ (Note 6)		200	300		200	300	mA
Power Supply Current	$V_S = \pm 15V$, $V_{OUT} = 0$		2.5	3.5		3.0	4.0	mA
Power Consumption	$V_S = \pm 15V$, $V_{OUT} = 0$		75	105		90	120	mW

ac electrical characteristics for LH0041/LH0041C ($T_A = 25^\circ C$, $V_S = \pm 15V$, $C_C = 3000$ pF)

PARAMETER	CONDITIONS	LH0041 MIN	LH0041 TYP	LH0041 MAX	LH0041C MIN	LH0041C TYP	LH0041C MAX	UNITS
Slew Rate	$A_V = +1$, $R_L = 100\Omega$	1.5	3.0		1.0	3.0		$V/\mu s$
Power Bandwidth	$R_L = 100\Omega$		40			40		kHz
Small Signal Transient Response			0.3	1.0		0.3	1.5	μs
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{IN} = 10V$, $A_V = +1$		4			4		μs
Overload Recovery Time			3			3		μs
Harmonic Distortion	f = 1 kHz, $P_O = 0.5W$		0.2			0.2		%
Input Noise Voltage	$R_S = 50\Omega$, B.W. = 10 Hz to 10 kHz		5			5		μV/rms
Input Noise Current	B.W. = 10 Hz to 10 kHz		0.05			0.05		nA/rms

Note 1: Rating applies for supply voltages above ±15V. For supplies less than ±15V, rating is equal to supply voltage.

Note 2: Rating applies for LH0041G and LH0021K with $R_{SC} = 0\Omega$.

Note 3: Rating applies as long as package power rating is not exceeded.

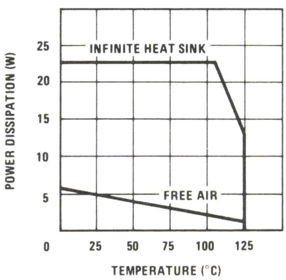
Note 4: Specifications apply for $\pm 5V \leq V_S \pm 18V$, and $-55^\circ C \leq T_C = \leq 125^\circ C$ for LH0021K and LH0041G, and $-25^\circ C \leq T_C \leq +85^\circ C$ for LH0021CK, LH0041CG and LH0041CJ unless otherwise specified. Typical values are for 25°C only.

Note 5: TO-8 "G" packages only.

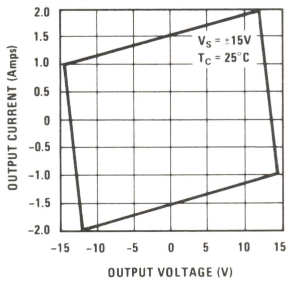
Note 6: Rating applies for "J" DIP package and for TO-8 "G" package with $R_{SC} = 3.3$ ohms.

typical performance characteristics

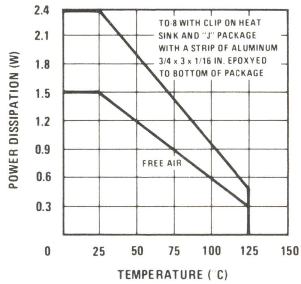
Power Derating-LH0021



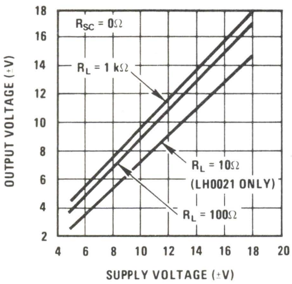
Safe Operating Area – LH0021



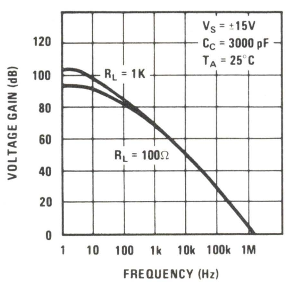
Package Power Dissipation LH0041/LH0041C



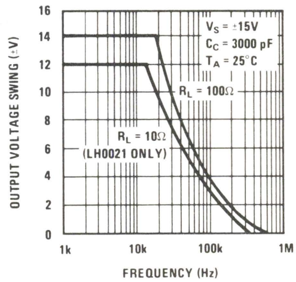
Output Voltage Swing



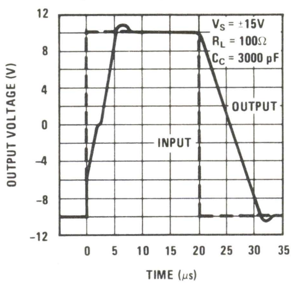
Open Loop Frequency Response



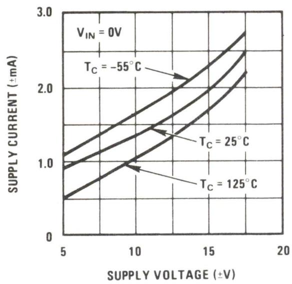
Large Signal Frequency Response



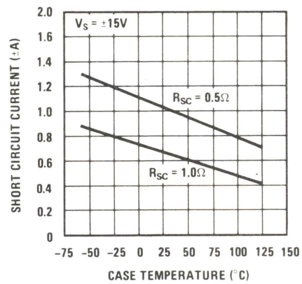
Voltage Follower Pulse Response



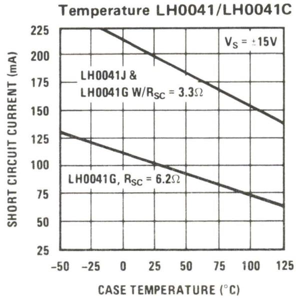
No Load Supply Current



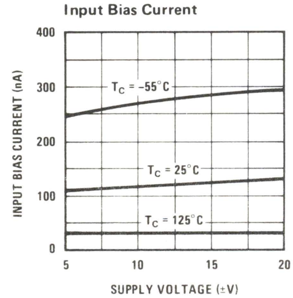
Short Circuit Current vs Temperature LH0021/LH0021C



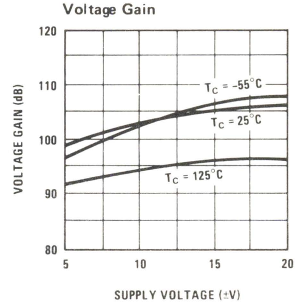
Short Circuit Current vs Temperature LH0041/LH0041C



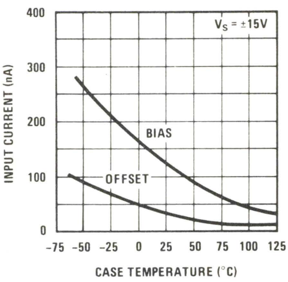
Input Bias Current

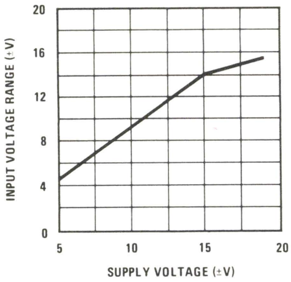


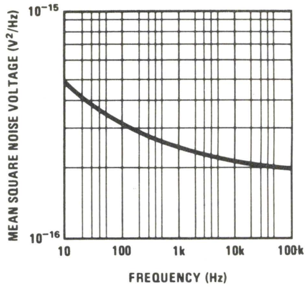
Voltage Gain

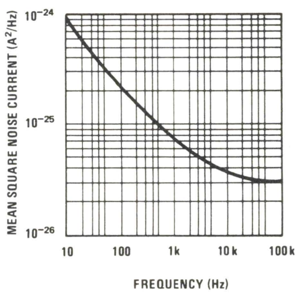


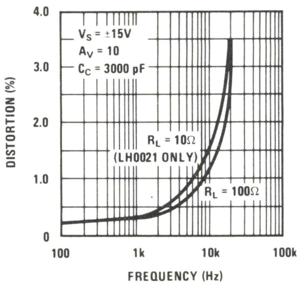
typical performance characteristics (con't)



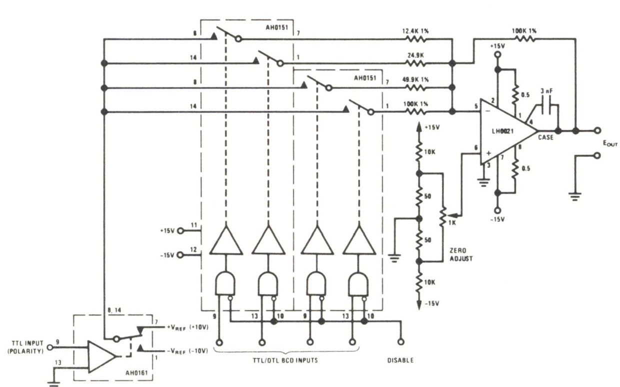




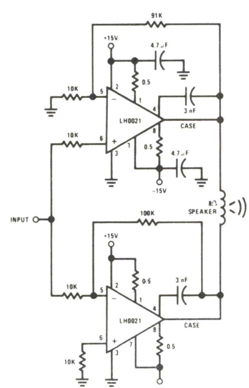




typical applications

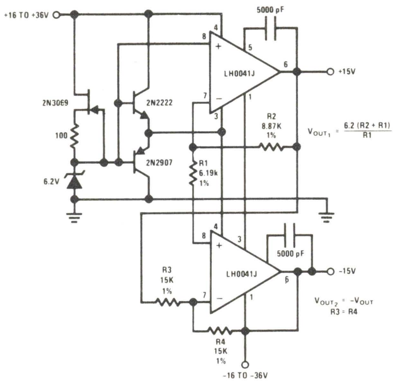


Programmable One Amp Power Supply

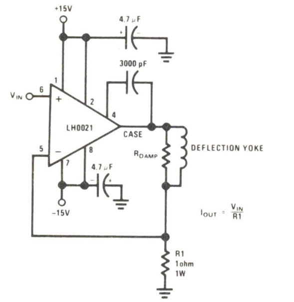


35 WATT (rms) Audio Amplifier

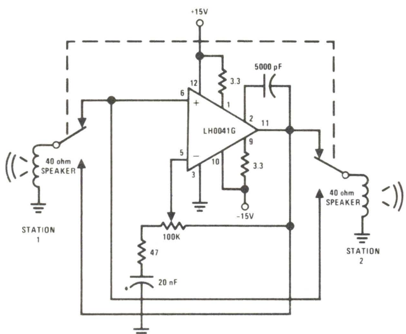
typical applications (con't)



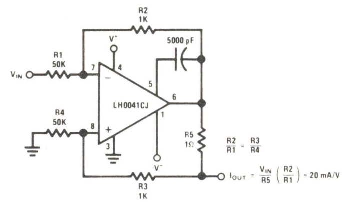
Dual Tracking One Amp Power Supply



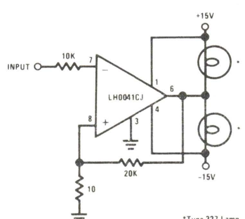
CRT Deflection Yoke Driver



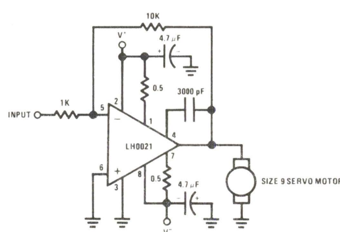
Two Way Intercom



Programmable High Current Source/Sink



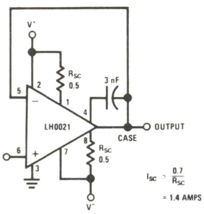
Power Comparator



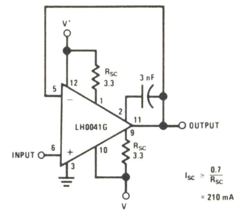
DC Servo Amplifier

2

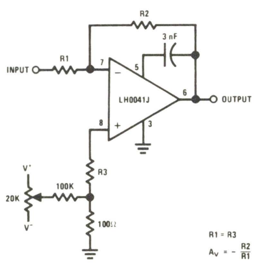
auxiliary circuits



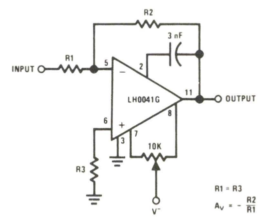
LH0021 Unity Gain Circuit with Short Circuit Limiting



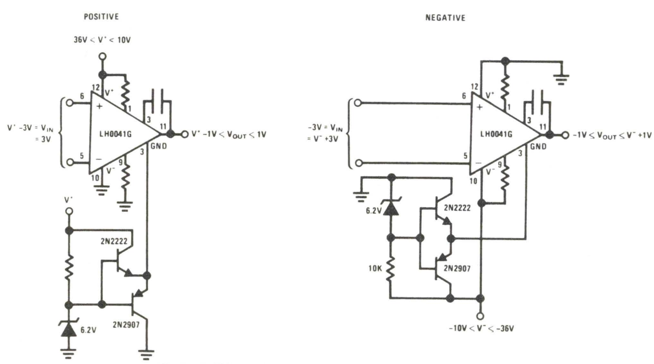
LH0041G Unity Gain with Short Circuit Limiting



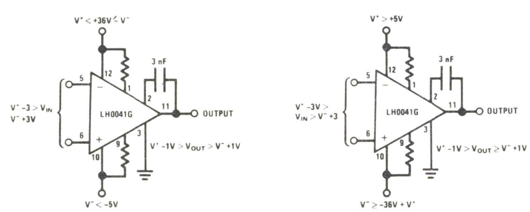
LH0041/LH0021 Offset Voltage Null Circuit (LH0041CJ Pin Connections Shown)*



LH0041G Offset Voltage Null Circuit



Operation from Single Supplies*



Operation from Non-Symmetrical Supplies

*For additional offset null circuit techniques see National Linear Applications Handbook.

Operational Amplifiers

LH0022/LH0022C* high performance FET op amp
LH0042/LH0042C low cost FET op amp
LH0052/LH0052C precision FET op amp

general description

The LH0022/LH0042/LH0052 are a family of FET input operational amplifiers with very closely matched input characteristics, very high input impedance, and ultra-low input currents with no compromise in noise, common mode rejection ratio, open loop gain, or slew rate. The internally laser nulled LH0052 offers 200 microvolts maximum offset and 5 μV/°C offset drift. Input offset current is less than 100 femtoamps at room temperature and 100 pA maximum at 125°C. The LH0022 and LH0042 are not internally nulled but offer comparable matching characteristics. All devices in the family are internally compensated and are free of latch-up and unusual oscillation problems. The devices may be offset nulled with a single 10k trimpot with neglible effect in offset drift or CMRR.

The LH0022, LH0042 and LH0052 are specified for operation over the −55°C to +125°C military temperature range. The LH0022C, LH0042C and LH0052C are specified for operation over the −25°C to +85°C temperature range.

features

- Low input offset current — 100 femtoamps max. (LH0052)
- Low input offset drift — 5 μV/°C max (LH0052)
- Low input offset voltage — 100 microvolts–typ.
- High open loop gain — 100 dB typ.
- Excellent slew rate — 3.0 V/μs typ.
- Internal 6 dB/octave frequency compensation
- Pin compatible with standard IC op amps (TO-5 package)

The LH0022/LH0042/LH0052 family of IC op amps are intended to fulfill a wide variety of applications for process control, medical instrumentation, and other systems requiring very low input currents and tightly matched input offsets. The LH0052 is particularly suited for long term high accuracy integrators and high accuracy sample and hold buffer amplifiers. The LH0022 and LH0042 provide low cost high performance for such applications as electrometer and photocell amplification, pico-ammeters, and high input impedance buffers.

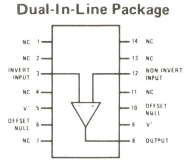
Special electrical parameter selection and custom built circuits are available on special request.

For additional application information and information on other National operational amplifiers, see *Available Linear Applications Literature.*

2

schematic and connection diagrams

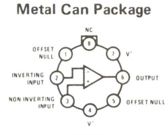
Dual-In-Line Package



TOP VIEW

Order Number LH0022D or LH0022CD or LH0042D or LH0042CD or LH0052D or LH0052CD
See Package 1

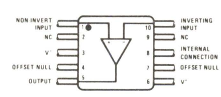
Metal Can Package



TOP VIEW

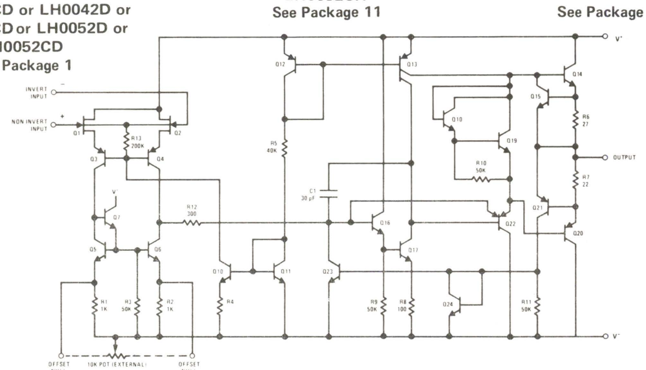
Order Number LH0022H or LH0022CH or LH0042H or LH0042CH or LH0052H or LH0052CH
See Package 11

Flat-Package



TOP VIEW

Order Number LH0022F or LH0022CF or LH0042F or LH0042CF
See Package 3



*Previously Called NH0022/NH0022C

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (see graph)	500 mW
Input Voltage (Note 1)	±15V
Differential Input Voltage (Note 2)	±30V
Voltage Between Offset Null and V^-	±0.5V
Short Circuit Duration	Continuous
Operating Temperature Range	
LH0022, LH0042, LH0052	−55°C to +125°C
LH0022C, LH0042C, LH0052C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics For LH0022/LH0022C (Note 3)

PARAMETER	CONDITIONS	LIMITS LH0022 MIN	LH0022 TYP	LH0022 MAX	LH0022C MIN	LH0022C TYP	LH0022C MAX	UNITS
Input Offset Voltage	$R_S \le 100\ k\Omega$; $T_A = 25°C$		2.0	4.0		3.5	6.0	mV
	$R_S \le 100\ k\Omega$			5.0			10.0	mV
Temperature Coefficient of Input Offset Voltage	$R_S \le 100\ k\Omega$		5	10		5	15	μV/°C
Offset Voltage Drift with Time			3			4		μV/week
Input Offset Current	$T_A = 25°C$		0.2	2.0		1.0	5.0	pA
				200			200	pA
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C		
Offset Current Drift with Time			0.1			0.1		pA/week
Input Bias Current	$T_A = 25°C$		5	10		10	25	pA
				1.0			1.0	nA
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C		
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range	$V_S = \pm 15V$	±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \le 10\ k\Omega$, $V_{IN} = \pm 10V$	80	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \le 10\ k\Omega$, $\pm 5V \le V_S \le \pm 15V$	80	90		70	90		dB
Large Signal Voltage Gain	$R_L = 2\ k\Omega$, $V_{OUT} = \pm 10V$, $T_A = 25°C$, $V_S = \pm 15V$	100	200		75	160		V/mV
	$R_L = 2\ k\Omega$, $V_{OUT} = \pm 10V$, $V_S = \pm 15V$	50			50			V/mV
Output Voltage Swing	$R_L = 1\ k\Omega$, $T_A = 25°C$, $V_S = \pm 15V$	±10	±12.5		±10	±12		V
	$R_L = 2\ k\Omega$, $V_S = \pm 15V$	±10			±10			V
Output Current Swing	$V_{OUT} = \pm 10V$, $T_A = 25°C$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			25			25		mA
Supply Current	$V_S = \pm 15V$		2.0	2.5		2.4	2.8	mA
Power Consumption	$V_S = \pm 15V$			75			85	mW

dc electrical characteristics for LH0042/LH0042C
($T_A = 25°C$, $V_S = \pm 15V$; unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS LH0042 MIN	LH0042 TYP	LH0042 MAX	LH0042C MIN	LH0042C TYP	LH0042C MAX	UNITS
Input Offset Voltage	$R_S \le 100$ kΩ; $\pm 5V \le V_S \le 20V$		5.0	20		6.0	20	mV
Temperature Coefficient of Input Offset Voltage	$R_S \le 100$ kΩ		5	20		10	25	μV/°C
Offset Voltage Drift with Time			7			10		μV/week
Input Offset Current			1	5		2	10	pA
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C		
Offset Current Drift with Time			0.1			0.1		pA/week
Input Bias Current			10	25		15	50	pA
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C		
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range		±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \le 10$ kΩ, $V_{IN} = \pm 10V$	70	86		70	80		dB
Supply Voltage Rejection Ratio	$R_S \le 10$ kΩ, $\pm 5V \le V_S \le \pm 15V$	70	86		70	80		dB
Large Signal Voltage Gain	$R_L = 1$ kΩ, $V_{OUT} = \pm 10V$	50	150		25	100		V/mV
Output Voltage Swing	$R_L = 1$ kΩ	±10	±12.5		±10	±12		V
Output Current Swing	$V_{OUT} = \pm 10V$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			20			20		mA
Supply Current			2.5	3.5		2.8	4.0	mA
Power Consumption				105			120	mW

dc electrical characteristics For LH0052/LH0052C (Note 3)

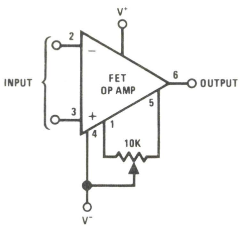
PARAMETER	CONDITIONS	LIMITS LH0052 MIN	LH0052 TYP	LH0052 MAX	LH0052C MIN	LH0052C TYP	LH0052C MAX	UNITS
Input Offset Voltage	$R_S \le 100$ kΩ; $V_S = \pm 15V$, $T_A = 25°C$		0.1	0.5		0.2	1.0	mV
	$R_S \le 100$ kΩ, $V_S = \pm 15V$			1.0			1.5	mV
Temperature Coefficient of Input Offset Voltage	$R_S \le 100$ kΩ		2	5		5	10	μV/°C
Offset Voltage Drift with Time			2			4		μV/week
Input Offset Current	$T_A = 25°C$		0.01	0.1		0.02	0.2	pA
				100			100	pA
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C		
Offset Current Drift with Time			<0.1			<0.1		pA/week
Input Bias Current	$T_A = 25°C$		0.5	1.0		1.0	5.0	pA
				500			500	pA
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C		
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range	$V_S = \pm 15V$	±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \le 10$ kΩ, $V_{IN} = \pm 10V$	80	90		76	90		dB
Supply Voltage Rejection Ratio	$R_S \le 10$ kΩ, $\pm 5V \le V_S \le \pm 15V$	80	90		76	90		dB
Large Signal Voltage Gain	$R_L = 2$ kΩ, $V_{OUT} = \pm 10V$, $V_S = \pm 15V$, $T_A = 25°C$	100	200		75	160		V/mV
	$R_L = 2$ kΩ, $V_{OUT} = \pm 10V$, $V_S = \pm 15V$	50			50			V/mV
Output Voltage Swing	$R_L = 1$ kΩ, $T_A = 25°C$ $V_S = \pm 15V$	±10	±12.5		±10	±12		V
	$R_L = 2$ kΩ, $V_S = \pm 15V$	±10			±10			V
Output Current Swing	$V_{OUT} = \pm 10V$, $T_A = 25°C$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			25			25		mA
Supply Current	$V_S = \pm 15V$		2.0	2.5		2.5	3.0	mA
Power Consumption	$V_S = \pm 15V$			75			90	mW

ac electrical characteristics For all amplifiers ($T_A = 25°C$, $V_S = \pm15V$)

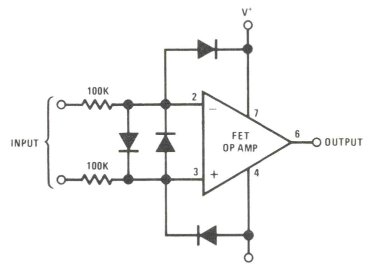
PARAMETER	CONDITIONS	LIMITS LH0022/42/52 MIN	TYP	MAX	LH0022C/42C/52C MIN	TYP	MAX	UNITS
Slew Rate	Voltage Follower	1.5	3.0		1.0	3.0		V/μs
Large Signal Bandwidth	Voltage Follower		40			40		kHz
Small Signal Bandwidth			1.0			1.0		MHz
Rise Time			0.3	1.5		0.3	1.5	μs
Overshoot			10	30		15	40	%
Settling Time (0.1 %)	$\Delta V_{IN} = 10V$		4.5			4.5		μs
Overload Recovery			4.0			4.0		μs
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 10$ Hz		150			150		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 100$ Hz		55			55		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 1$ kHz		35			35		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 10$ kHz		30			30		$nV/\sqrt{Hz}$
Input Noise Voltage	BW = 10 Hz to 10 kHz, $R_S = 10\ k\Omega$		12			12		μVrms
Input Noise Current	BW = 10 Hz to 10 kHz		<.1			<.1		pArms

Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 2: Rating applies for minimum source resistance of 10 kΩ, for source resistances less than 10 kΩ, maximum differential input voltage is ±5V.
Note 3: Unless otherwise specified, these specifications apply for $\pm5V \le V_S \le \pm20V$ and $-55°C \le T_A \le +125°C$ for the LH0022, LH0042 and LH0052 and $-25°C \le T_A$ +85°C for the LH0022C, LH0042C and LH0052C. Typical values are given for $T_A = 25°C$.

auxiliary circuits (shown for TO-5 pin out)

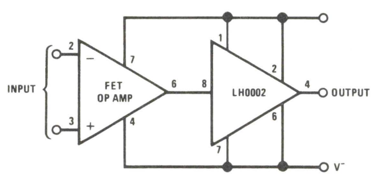


Offset Null



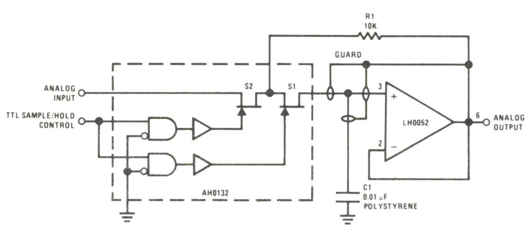
Note: All diodes are ultra low leakage

Protecting Inputs From ±150V Transients

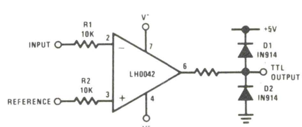


Boosting Output Drive to ±100 mA

typical applications

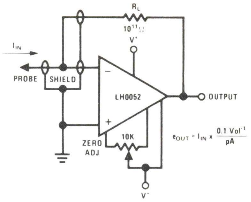


Alternate Low Drift Sample

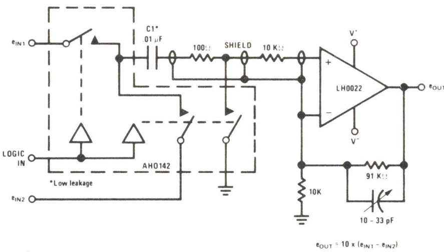


Precision Voltage Comparator

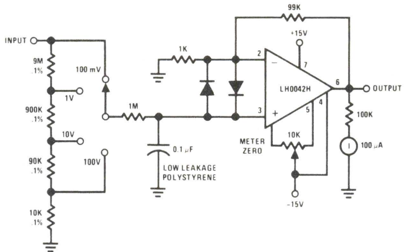
typical applications (con't)



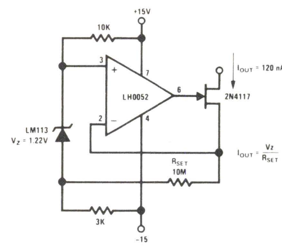
Picoamp Amplifier for pH Meters and Radiation Detectors



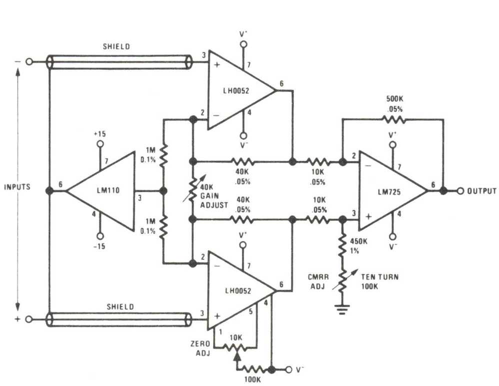
Precision Subtractor for Automatic Test Gear



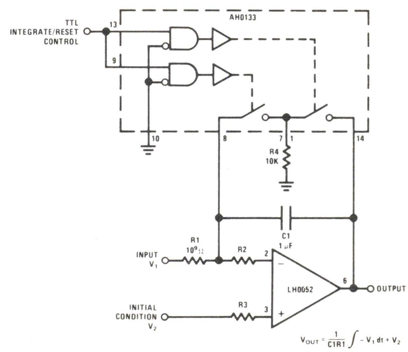
Sensitive Low Cost "VTVM"



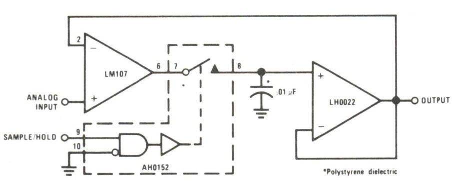
Ultra Low Level Current Source



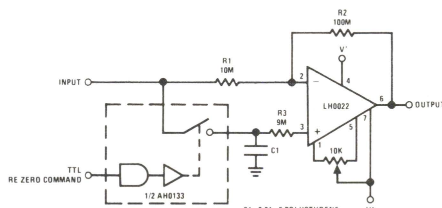
True Instrumentation Amplifier



Precision Integrator



Precision Sample and Hold

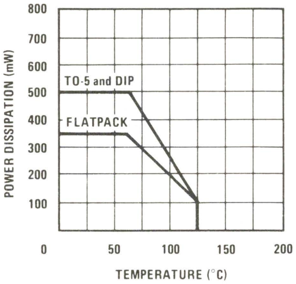


Re-Zeroing Amplifier

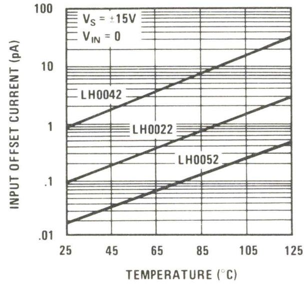
2

typical performance characteristics

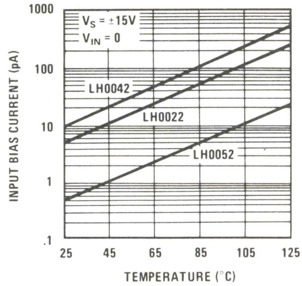
Maximum Power Dissipation



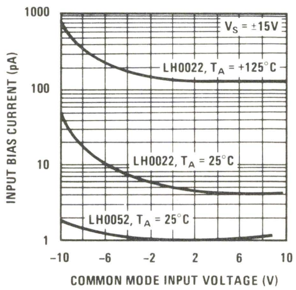
Input Offset Current vs Temperature



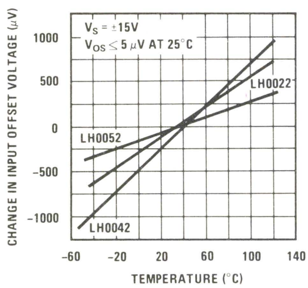
Input Bias Current vs Temperature



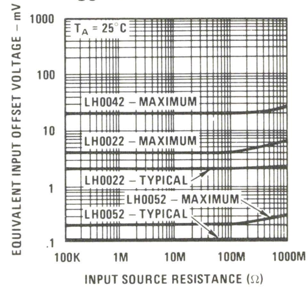
Input Bias Current vs Input Voltage



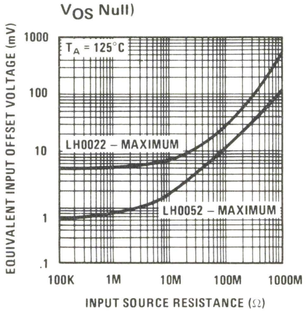
Input Offset Current vs Temperature



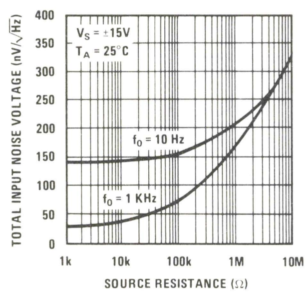
Offset Error (Without V_{OS} Null)



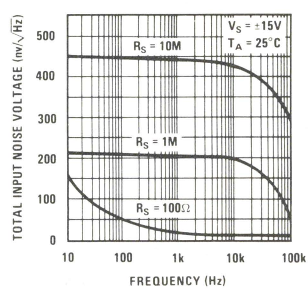
Offset Error (Without V_{OS} Null)



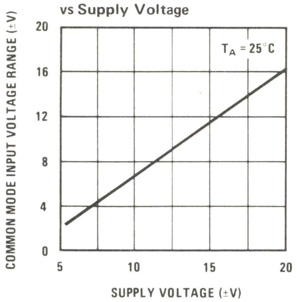
Total Input Noise Voltage* vs Source Resistance



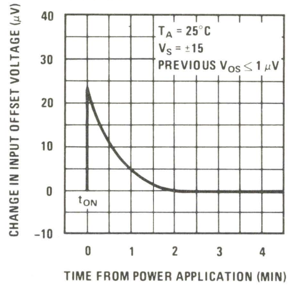
Total Input Noise Voltage* vs Frequency



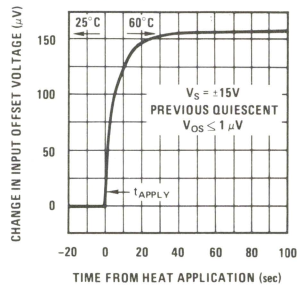
Common Mode Input Voltage vs Supply Voltage



Stabilization Time of Input Offset Voltage from Power Turn-On



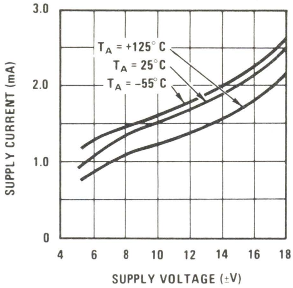
Change in Input Offset Voltage Due to Thermal Shock vs Time



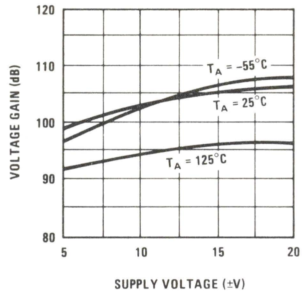
*Noise Voltage Includes Contribution from Source Resistance

typical performance characteristics (con't)

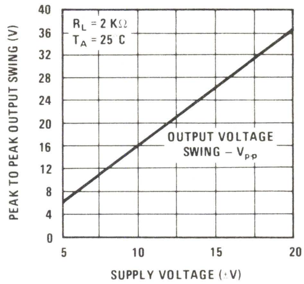
Supply Voltage vs Supply Current



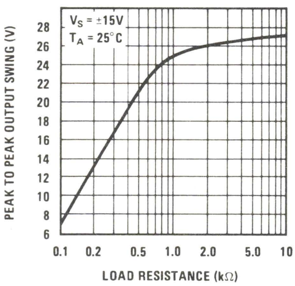
Voltage Gain



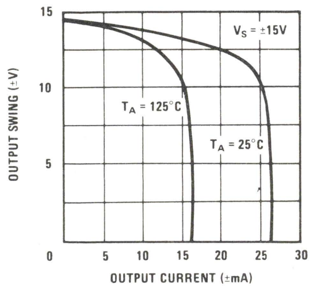
Output Swing vs Supply Voltage



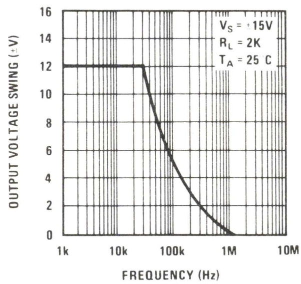
Output Voltage Swing vs Load Resistance



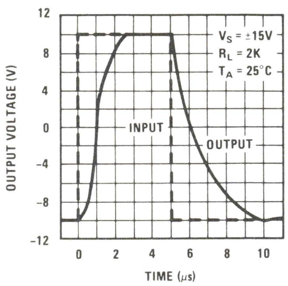
Current Limiting



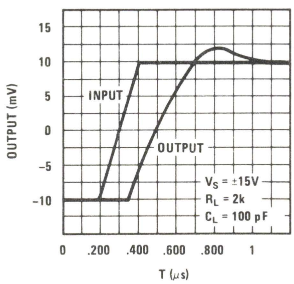
Output Voltage Swing vs Frequency



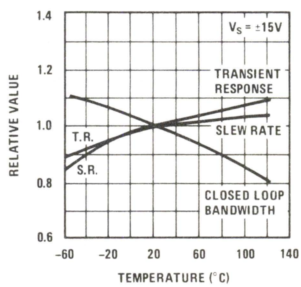
Voltage Follower Large Signal Response



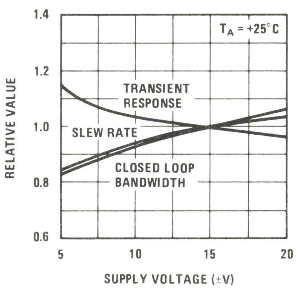
Transient Response



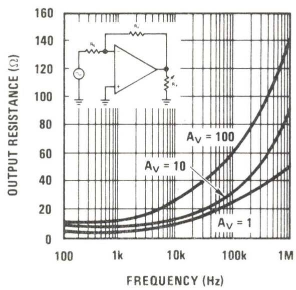
Frequency Characteristics vs Ambient Temperature



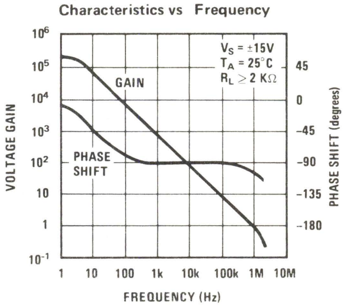
Frequency Characteristics vs Supply Voltage



Output Resistance vs Frequency



Open Loop Transfer Characteristics vs Frequency



2

Operational Amplifiers

LH0023/LH0023C, LH0043/LH0043C sample and hold circuits

general description

The LH0023/LH0023C and LH0043/LH0043C are complete sample and hold circuits including input buffer amplifier, FET output amplifier, analog signal sampling gate, TTL compatible logic circuitry and level shifting. They are designed to operate from standard ±15V DC supplies, but provision is made on the LH0023/LH0023C for connection of a separate +5V logic supply in minimum noise applications. The principal difference between the LH0023/LH0023C and the LH0043/LH0043C is a 10:1 trade-off in performance on sample accuracy vs sample acquisition time. Devices are pin compatible except that TTL logic is inverted between the two types.

The LH0023/LH0023C and LH0043/LH0043C are ideally suited for a wide variety of sample and hold applications including data acquisition, analog to digital conversion, synchronous demodulation, and automatic test setup. They offer significant cost and size reduction over equivalent module or discrete designs. Each device is available in a hermetic TO-8 package and are completely specified over both full military and instrument temperature ranges.

The LH0023 and LH0043 are specified for operation over the −55°C to +125°C military temperature range. The LH0023C and LH0043C are specified for operation over the −25°C to +85°C temperature range.

For information on other National analog products, see *Available Linear Applications Literature.*

features

LH0023/LH0023C

- Sample accuracy—0.01% max
- Hold draft rate—0.5 mV/sec typ
- Sample acquisition time—100 μs max for 20V
- Aperture time—150 ns typ
- Wide analog range—±10V min
- Logic input—TTL/DTL
- Offset adjustable to zero with single 10k pot
- Output short circuit proof

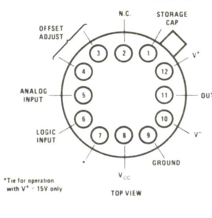
features

LH0043/LH0043C

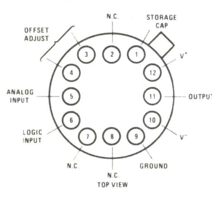
- Sample acquisition time—15 μs max for 20V
  4 μs typ for 5V
- Aperture time—20 nS typ
- Hold drift rate—1 mV/sec typ
- Sample accuracy—0.1% max
- Wide analog range—±10V min
- Logic input—TTL/DTL
- Offset adjustable to zero with single 10k pot
- Output short circuit proof

block and connection diagrams

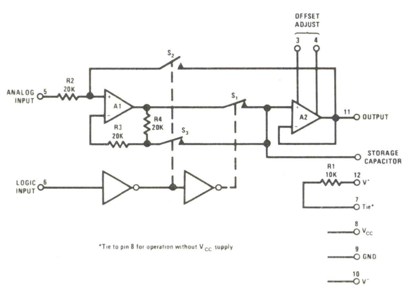
LH0023/LH0023C

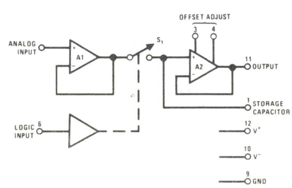


LH0043/LH0043C



Order Number LH0023G or LH0023CG or LH0043G or LH0043CG
See Package 6





absolute maximum ratings

Supply Voltage (V^+ and V^-)		±20V
Logic Supply Voltage (V_{CC}) LH0023, LH0023C		+7.0V
Logic Input Voltage (V_6)		+5.5V
Analog Input Voltage (V_5)		±15V
Power Dissipation		See graph
Output Short Circuit Duration		Continuous
Operating Temperature Range	LH0023, LH0043	−55°C to +125°C
	LH0023C, LH0043C	−25°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Soldering (10 sec)		300°C

electrical characteristics LH0023/LH0023C (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0023			LH0023C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Sample (Logic "1") Input Voltage	V_{CC} = 4.5V	2.0			2.0			V
Sample (Logic "1") Input Current	V_6 = 2.4V, V_{CC} = 5.5V			5.0			5.0	μA
Hold (Logic "0") Input Voltage	V_{CC} = 4.5V			0.8			0.8	V
Hold (Logic "0") Input Current	V_6 = 0.4V, V_{CC} = 5.5V			0.5			0.5	mA
Analog Input Voltage Range		±10	±11		±10	±11		V
Supply Current – I_{10}	V_5 = 0V, V_6 = 2V, V_{11} = 0V		4.5	6		4.5	6	mA
Supply Current – I_{12}	V_5 = 0V, V_6 = 0.4V, V_{11} = 0V		4.5	6		4.5	6	mA
Supply Current – I_8	V_8 = 5.0V, V_5 = 0		1.0	1.6		1.0	1.6	mA
Sample Accuracy	V_{OUT} = ±10V (Full Scale)		0.002	0.01		0.002	0.01	%
DC Input Resistance	Sample Mode	500	1000		300	1000		kΩ
	Hold Mode	20	25		20	25		kΩ
Input Current – I_5	Sample Mode		0.2	1.0		0.3	1.5	μA
Input Capacitance			3.0			3.0		pF
Leakage Current – pin 1	V_5 = ±10V; V_{11} = ±10V, T_A = 25°C		100	200		200	500	pA
	V_5 = ±10V; V_{11} = ±10V		0.6	1.0		1.0	2	nA
Drift Rate	V_{OUT} = ±5V, C_S = 0.01 μF, T_A = 25°C		0.5			0.5		mV/s
Drift Rate	V_{OUT} = ±10V, C_S = 0.01 μF, T_A = 25°C		10	20		20	50	mV/s
Drift Rate	V_{OUT} = ±10V, C_S = 0.01 μF			0.1			0.2	mV/ms
Aperture Time			150			150		ns
Sample Acquisition Time	ΔV_{OUT} = 20V, C_S = 0.01 μF		50	100		50	100	μs
Output Amplifier Slew Rate		1.5	3.0		1.5	3.0		V/μs
Output Offset Voltage (without null)	$R_S \leq$ 10k, V_5 = 0V, V_6 = 0V			±20			±20	mV
Analog Voltage Output Range	$R_L \geq$ 1k, T_A = 25°C	±10	±11		±10	±11		V
	$R_L \geq$ 2k	±10	±12		±10	±12		V

NOTE 1: Unless otherwise noted, these specifications apply for V^+ = +15V, V_{CC} = +5V, V^- = −15V, pin 9 grounded, a 0.01 μF capacitor connected between pin 1 and ground over the temperature range −55°C to +125°C for the LH0023, and −25°C to 85°C for the LH0023C. All typical values are for T_A = 25°C.

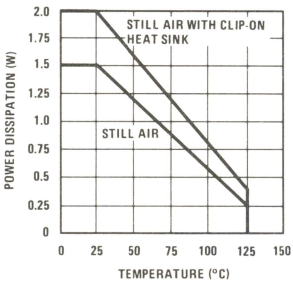
electrical characteristics LH0043/LH0043C: (Note 2)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0043			LH0043C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Hold (Logic "1") Input Voltage		2.0			2.0			V
Hold (Logic "1") Input Current	$V_6 = 2.4V$			5.0			5.0	μA
Sample (Logic "0") Input Voltage				0.8			0.8	V
Sample (Logic "0") Input Current	$V_6 = 0.4V$			1.5			1.5	mA
Analog Input Voltage Range		±10	±11		±10	±11		V
Supply Current	$V_5 = 0V, V_6 = 2V, V_{11} = 0V$		20	22		20	22	mA
	$V_5 = 0V, V_6 = 0.4V, V_{11} = 0V$		14	18		14	18	mA
Sample Accuracy	$V_{OUT} = \pm 10V$ (Full Scale)		0.02	0.1		0.02	0.3	%
DC Input Resistance	$T_C = 25°C$	10^{10}	10^{12}		10^{10}	10^{12}		Ω
Input Current – I_5			1.0	5.0		2.0	10.0	nA
Input Capacitance			1.5			1.5		pF
Leakage Current– pin 1	$V_5 = \pm 10V; V_{11} = \pm 10, T_C = 25°C$		10	25		20	50	pA
	$V_5 = \pm 10V; V_{11} = \pm 10V$		10	25		2	5	nA
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.001\ \mu F, T_A = 25°C$		10	25		20	50	mV/s
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.001\ \mu F$		10	25		2	5	mV/ms
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.01\ \mu F, T_A = 25°C$		1	2.5		2	5	mV/s
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.01\ \mu F$		1	2.5		0.2	0.5	mV/ms
Aperture Time			20	60		20	60	ns
Sample Acquisition Time	$\Delta V_{OUT} = 20V, C_S = 0.001\ \mu F$		10	15		10	15	μs
	$\Delta V_{OUT} = 20V, C_S = 0.01\ \mu F$		30	50		30	50	μs
	$\Delta V_{OUT} = 5V, C_S = 0.001\ \mu F$		4			4		μs
Output Amplifier Slew Rate	$V_{OUT} = 5V, C_S = 0.001\ \mu F$	1.5	3.0		1.5	3.0		$V/\mu s$
Output Offset Voltage (without null)	$R_S \leq 10k, V_5 = 0V, V_6 = 0V$			±40			±40	mV
Analog Voltage Output Range	$R_L \geq 1k, T_A = 25°C$	±10	±11		±10	±11		V
	$R_L \geq 2k$	±10	±12		±10	±12		V

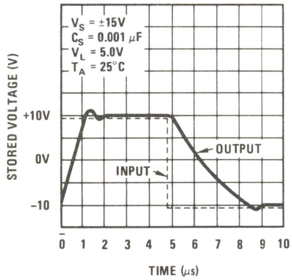
Note 2: Unless otherwise noted, these specifications apply for $V^+ = +15V$, $V^- = -15V$, pin 9 grounded, a 5000 pF capacitor connected between pin 1 and ground over the temperature range −55°C to +125°C for the LH0043, and −25°C to 85°C for the LH0043C. All typical values are for $T_C = 25°C$.

typical performance characteristics

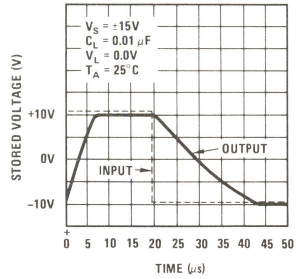
Power Dissipation



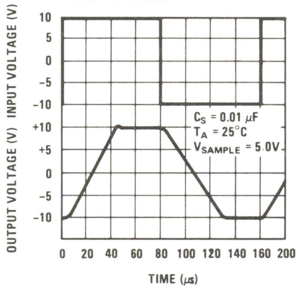
Sample Acquisition Time—LH0043



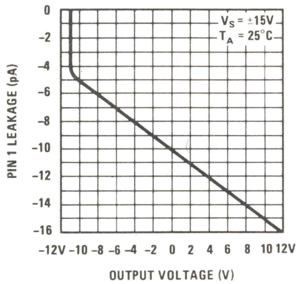
Sample Acquisition Time—LH0043



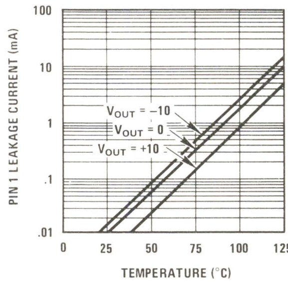
Sample Acquisition Time—LH0023



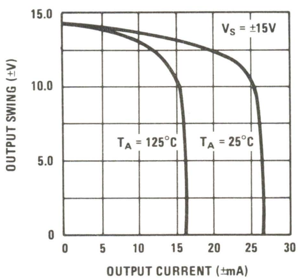
Pin 1 Leakage Current vs Output Voltage



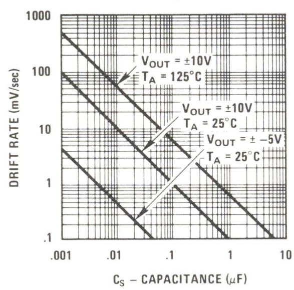
Pin 1 Leakage Current vs Temperature



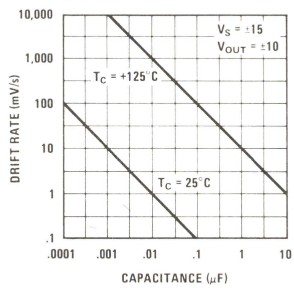
Output Current Limiting



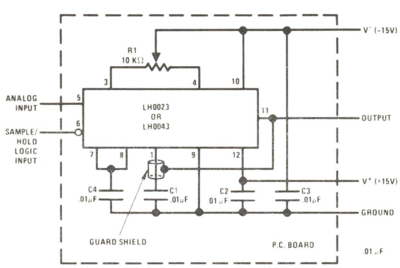
Drift Rate vs Capacitance



Drift vs Capacitance (LH0043)



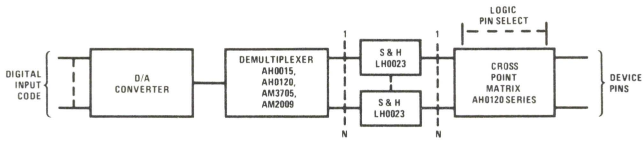
typical applications



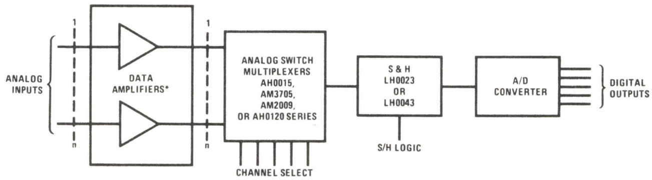
Note 1: C1 is polystyrene
Note 2: C2, C3, C4 are ceramic disc
Note 3: Jumper 7–8 and C4 not required for LH0043
Note 4: R1 optional if zero trim is required

How to Build a Sample and Hold Module

typical applications (con't)

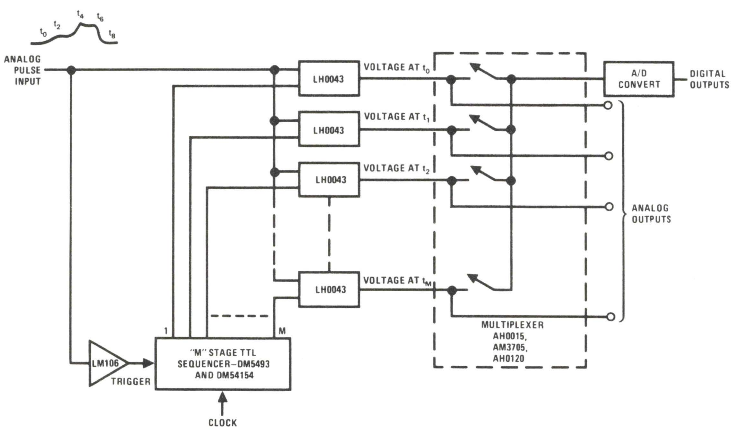


Forcing Function Setup for Automatic Test Gear

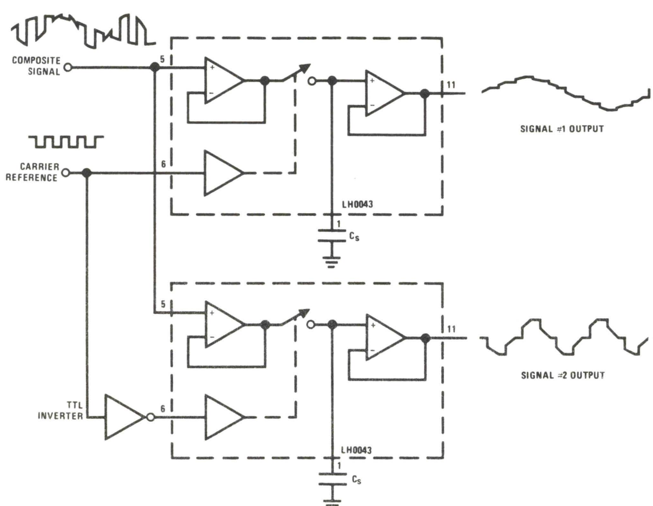


*See op. amp. selection guide for details. Most popular types include LH0052, LH1725, LM108, LM112 and LM116.

Data Acquisition System



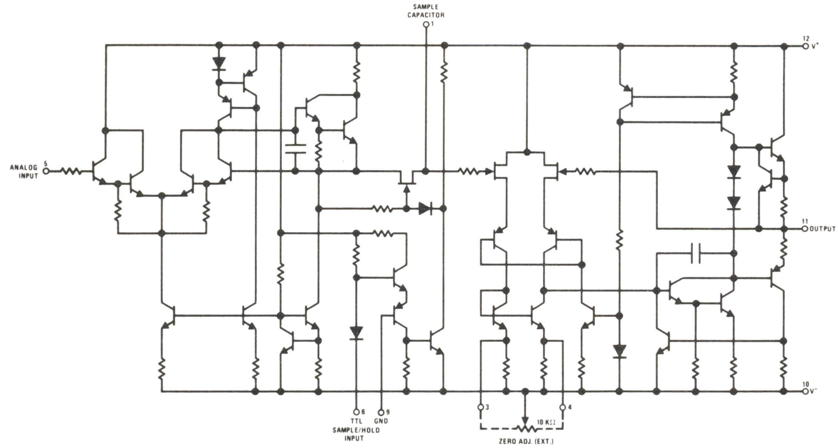
Single Pulse Sampler



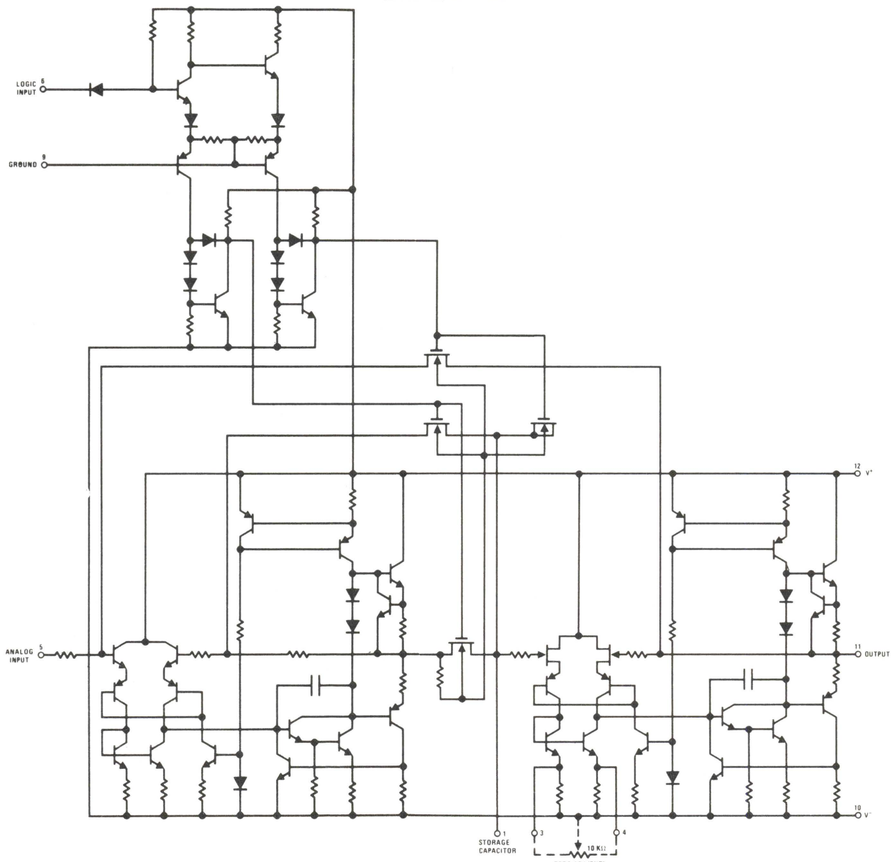
Two Channel Double Sideband Demodulator

schematic diagrams

LH0043/LH0043C



LH0023/LH0023C



applications information

1.0 Drift Error Minimization

In order to minimize drift error, care in selection of C_S and layout of the printed circuit board is required. The capacitor should be of high quality Teflon, polycarbonate, or polystyrene construction. Board cleanliness and layout are critical particularly at elevated temperatures. See AN-63 for detailed recommendations. A guard conductor connected to the output surrounding the storage node (pin 1) will be helpful in meeting severe environmental conditions which would otherwise cause leakage across the printed circuit board.

2.0 Capacitor Selection

The size of the capacitor is dictated by the required drift rate and acquisition time. The drift is determined by the leakage current at pin 1 and may be calculated by $\frac{dV}{dt} = \frac{I_L}{C_S}$, where I_L is the total leakage current at pin 1 of the device, and C_S is the value of the storage capacitor.

2.1 Capacitor Selection — LH0023

At room temperature leakage current for the LH0023 is approximately 100 pA. A drift rate of 10 mV/sec would require a 0.01 μF capacitor.

For values of C_S up to 0.01 μF the acquisition time is limited by the slew rate of the input buffer amplifier, A1, typically 0.5 V/μs. Beyond this point, current availability to charge C_S also enters the picture. The acquisition time is given by:

$$t_A \cong \sqrt{\frac{2\Delta e_O RC_S}{0.5 \times 10^6}} = 2 \times 10^{-3}\sqrt{\Delta e_O RC_S}$$

where: R = the internal resistance in series with C_S

Δe_O = change in voltage sampled

An average value for R is approximately 600 ohms. The expression for t_A reduces to:

$$t_A \cong \frac{\sqrt{\Delta e_O C_S}}{20}$$

For a −10V to +10V change and C_S = .05 μF, acquisition time is typically 50 μs.

2.2 Capacitor Selection—LH0043

At 25°C case temperature, the leakage current for the LH0043G is approximately 10 pA, so a drift rate of 5 mV/s would require a capacitor of $C_S = 10 \cdot 10^{-12}/5 \cdot 10^{-3}$ = 2000 pF or larger.

For values of C_S below about 5000 pF, the acquisition time of the LH0043G will be limited by the slew rate of the output amplifier (the signal will be acquired, in the sense that the voltage will be stored on the capacitor, in much less time as dictated by the slew rate and current capacity of the input amplifier, but it will not be available at the output). For larger values of storage capacitance, the limitation is the current sinking capability of the input amplifier, typically 10 mA. With C_S = 0.01 μF, the slew rate can be estimated by $\frac{dV}{dt} = \frac{10 \cdot 10^{-3}}{0.01 \cdot 10^{-6}}$ = 1V/μs or a slewing time for a 5 volt signal change of 5μs.

3.0 Offset Null

Provision is made to null both the LH0023 and LH0043 by use of a 10k pot between pins 3 and 4. Offset null should be accomplished in the sample mode at one half the input voltage range for minimum average error.

4.0 Switching Spike Minimization—LH0043

A capacitive divider is formed by the storage capacitor and the capacitance of the internal FET switch which causes a small error current to be injected into the storage capacitor at the termination of the sample interval. This can be considered a negative DC offset and nulled out as described in (3.0), or the transient may be nulled by coupling an equal but opposite signal to the storage capacitor. This may be accomplished by connecting a capacitor of about 30 pF (or a trimmer) between the logic input (pin 6) and the storage capacitor (pin 1). Note that this capacitor must be chosen as carefully as the storage capacitor itself with respect to leakage. The LH0023 has switch spike minimization circuitry built into the device.

5.0 Elimination of the 5V Logic Supply—LH0023

The 5V logic supply may be eliminated by shorting pin 7 to pin 8 which connects a 10k dropping resistor between the +15V and V_C. Decoupling pin 8 to ground through 0.1 μF disc capacitor is recommended in order to minimize transients in the output.

6.0 Heat Sinking

The LH0023 and LH0043G may be operated without damage throughout the military temperature range of −55 to +125°C (−25 to +85°C for the LH0023CG and LH0043CG) with no explicit heat sink, however power dissipation will cause the internal temperature to rise above ambient. A simple clip-on heat sink such as Wakefield #215–1.9 or equivalent will reduce the internal temperature about 20°C thereby cutting the leakage current and drift rate by one fourth at max. ambient. There is no internal electrical connection to the case, so it may be mounted directly to a grounded heat sink.

7.0 Theory of Operation—LH0023

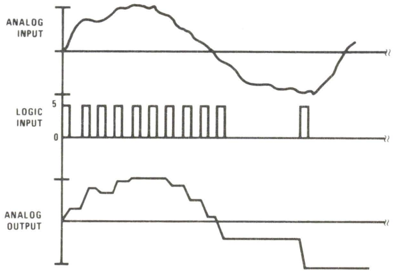
The LH0023/LH0023C is comprised of input buffer amplifier, A1, analog switches, S1 and S2, a

applications information (con't)

TTL to MOS level translator, and output buffer amplifier, A2. In the "sample" mode, the logic input is raised to logic "1" ($V_6 \geq 2.0V$) which opens S1 and closes S2. Storage capacitor, C_S, is charged to the input voltage through S2 and the output slews to the input voltage. In the "hold" mode, the logic input is lowered to logic "0" ($V_6 \leq 0.8V$) opening S2 and closing S1. C_S retains the sample voltage which is applied to the output via A2. Since S1 is closed, the input signal is overridden, and leakage across the MOS switch is therefore minimized. With S2 open, drift is primarily determined by input bias current of A2, typically 100 pA at 25°C.

7.1 Theory of Operation—LH0043

The LH0043/LH0043C is comprised of input buffer amplifier A1, FET switch S1 operated by a TTL compatible level translator, and output buffer amplifier A2. To enter the "sample" mode, the logic input is taken to the TTL logic "0" state ($V_6 = 0.8V$) which commands the switch S1 closed and allows A1 to make the storage capacitor voltage equal to the analog input voltage. In the "hold" mode ($V_6 = 2.0V$), S1 is opened isolating the storage capacitor from the input and leaving it charged to a voltage equal to the last analog input voltage before entering the hold mode. The storage capacitor voltage is brought to the output by low leakage amplifier A2.



8.0 Definitions

- V_5: The voltage at pin 5, e.g., the analog input voltage.
- V_6: The voltage at pin 6, e.g., the logic control input signal.
- V_{11}: The voltage at pin 11, e.g., the output signal.
- T_A: The temperature of the ambient air.
- T_C: The temperature of the device case at the center of the bottom of the header.

Acquisition Time:
The time required for the output (pin 11) to settle within the rated accuracy after a specified input change is applied to the input (pin 5) with the logic input (pin 6) in the low state.

Aperture Time:
The time indeterminacy when switching from sample mode to hold including the delay from the time the mode control signal (pin 6) passes through its threshold (1.4 volts) to the time the circuit actually enters the hold mode.

Output Offset Voltage:
The voltage at the output terminal (pin 11) with the analog input (pin 5) at ground and logic input (pin 6) in the "sample" mode. This will always be adjustable to zero using a 10k pot between pins 3 and 4 with the wiper arm returned to V^-.

Operational Amplifiers

LH0024/LH0024C high slew rate operational amplifier

general description

The LH0024/LH0024C is a very wide bandwidth, high slew rate operational amplifier intended to fulfill a wide variety of high speed applications such as buffers to A to D and D to A converters and high speed comparators. The device exhibits useful gain in excess of 50 MHz making it possible to use in video applications requiring higher gain accuracy than is usually associated with such amplifiers.

features

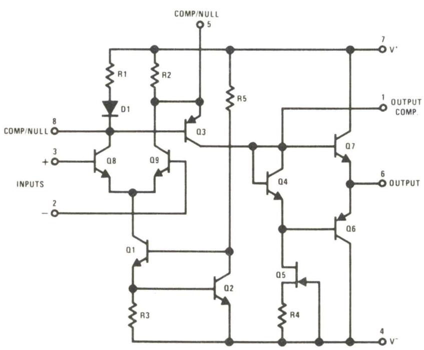
- Very high slew rate — 500 V/μs at Av = +1
- Wide small signal bandwidth — 70 MHz
- Wide large signal bandwidth — 15 MHz
- High output swing — ±12V into 1K
- Offset null with single pot
- Low input offset — 2 mV
- Pin compatible with standard IC op amps

The LH0024/LH0024C's combination of wide bandwidth and high slew rate make it an ideal choice for a variety of high speed applications including active filters, oscillators, and comparators as well as many high speed general purpose applications.

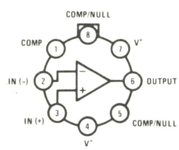
The LH0024 is guaranteed over the temperature range −55°C to +125°C, whereas the LH0024C is guaranteed −25°C to +85°C.

For information on other National operational amplifiers, see listing on last page.

schematic and connection diagrams



Metal Can Package



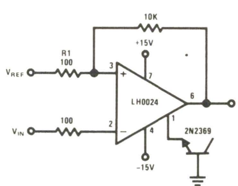
TOP VIEW

Note: For heat sink use Thermalloy 2230-5 series.

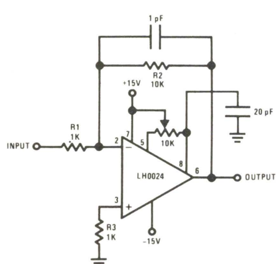
Order Number LH0024H or LH0024CH
See Package 11

typical applications

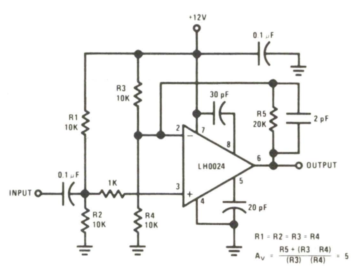
TTL Compatible Comparator



Offset Null



Video Amplifier



absolute maximum ratings

Supply Voltage		±18V
Input Voltage		Equal to Supply
Differential Input Voltage		±5V
Power Dissipation		600 mW
Operating Temperature Range	LH0024	$-55^\circ C$ to $+125^\circ C$
	LH0024C	$-25^\circ C$ to $+85^\circ C$
Storage Temperature Range		$-65^\circ C$ to $+150^\circ C$
Lead Temperature (Soldering, 10 sec)		$300^\circ C$

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0024			LH0024C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 50\Omega$, $T_A = 25^\circ C$ $R_S = 50\Omega$		2.0	4.0 6.0		5.0	8.0 10.0	mV mV
Average Temperature Coefficient of Input Offset Voltage	$V_S = \pm15V$, $R_S = 50\Omega$ $-55^\circ C$ to $125^\circ C$		20			25		$\mu V/^\circ C$
Input Offset Current	$T_A = 25^\circ C$		2.0	5.0 10.0		4.0	15.0 20.0	μA μA
Input Bias Current	$T_A = 25^\circ C$		15	30 40		18	40 50	μA μA
Supply Current			12.5	13.5		12.5	13.5	mA
Large Signal Voltage Gain	$V_S = \pm15V$, $R_L = 1k$, $T_A = 25^\circ C$ $V_S = \pm15V$, $R_L = 1k$	4 3	5		3 2.5	4		V/mV V/mV
Input Voltage Range	$V_S = \pm15V$	±12	±13		±12	±13		V
Output Voltage Swing	$V_S = \pm15V$, $R_L = 1k$, $T_A = 25^\circ C$ $V_S = \pm15V$, $R_L = 1k$	±12 ±10	±13		±10 ±10	±13		V V
Slew Rate	$V_S = \pm15V$, $R_L = 1k$, $C_1 = C_2 = 30$ pF $A_V = +1$, $T_A = 25^\circ C$	400	500		250	400		$V/\mu s$
Common Mode Rejection Ratio	$V_S = \pm15V$, $\Delta V_{IN} = \pm10V$ $R_S = 50\Omega$		60			60		dB
Power Supply Rejection Ratio	$\pm5V \le V_S \le \pm18V$ $R_S = 50\Omega$		60			60		dB

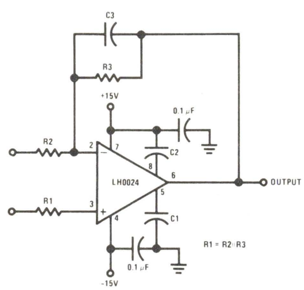
Note 1: These specifications apply for $\pm5V \le V_S \le \pm18V$ and $-55^\circ C$ to $+125^\circ C$ for the LH0024 and $-25^\circ C$ to $+85^\circ C$ for the LH0024C.

frequency compensation

TABLE I

CLOSED LOOP GAIN	C_1	C_2	C_3
100	0	0	0
20	0	0	0
10	0	20 pF	1 pF
1	30 pF	30 pF	3 pF

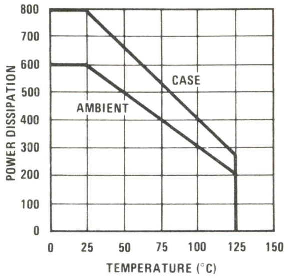
Frequency Compensation Circuit



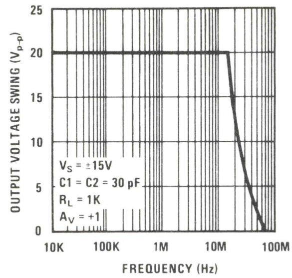
2

typical performance characteristics

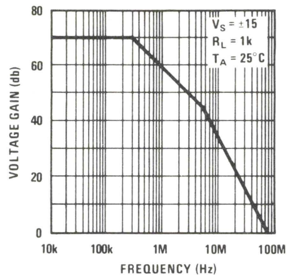
Maximum Power Dissipation



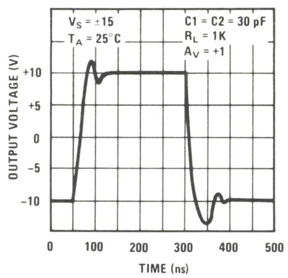
Large Signal Frequency Response



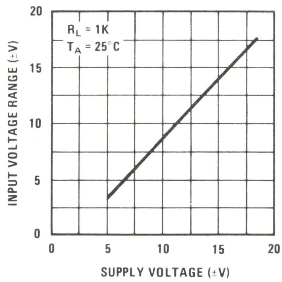
Open Loop Frequency Response



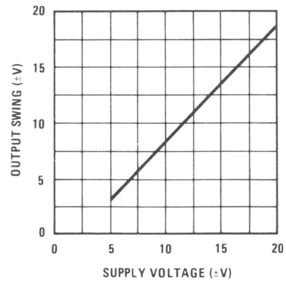
Voltage Follower Pulse Response



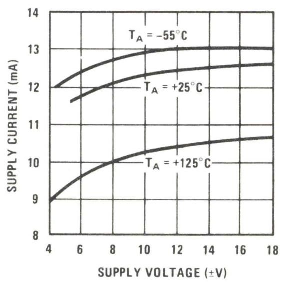
Input Voltage vs Supply Voltage



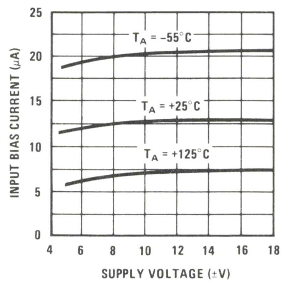
Output Voltage Swing



Supply Current vs Supply Voltage



Input Bias Current vs Voltage



applications information

1. Layout Considerations

The LH0024/LH0024C, like most high speed circuitry, is sensitive to layout and stray capacitance. Power supplies should be by-passed as near the device as is practicable with at least .01 μF disc type capacitors. Compensating capacitors should also be placed as close to device as possible.

2. Compensation Recommendations

Compensation schemes recommended in Table 1 work well under typical conditions. However, poor layout and long lead lengths can degrade the performance of the LH0024 or cause the device to oscillate. Slight adjustments in the values for C1, C2, and C3 may be necessary for a given layout. In particular, when operating at a gain of −1, C3 may require adjustment in order to perfectly cancel the input capacitance of the device.

When operating the LH0024/LH0024C at a gain of +1, the value of R1 should be at least 1K ohm.

The case of the LH0024 is electrically isolated from the circuit; hence, it may be advantageous to drive the case in order to minimize stray capacitances.

3. Heat Sinking

The LH0024/LH0024C is specified for operation without the use of an explicit heat sink. However, internal power dissipation does cause a significant temperature rise. Improved offset voltage drift can be obtained by limiting the temperature rise with a clip-on heat sink such as the Thermalloy 2228B or equivalent.

Operational Amplifiers

LH0032/LH0032C ultra fast FET operational amplifier

general description

The LH0032/LH0032C is a high slew rate, high input impedance differential operational amplifier suitable for diverse application in fast signal handling. The high allowable differential input voltage, ease of output clamping, and high output drive capability particularly suit it for comparator applications. It may be used in applications normally reserved for video amplifiers allowing the use of operational gain setting and frequency response shaping into the megahertz region.

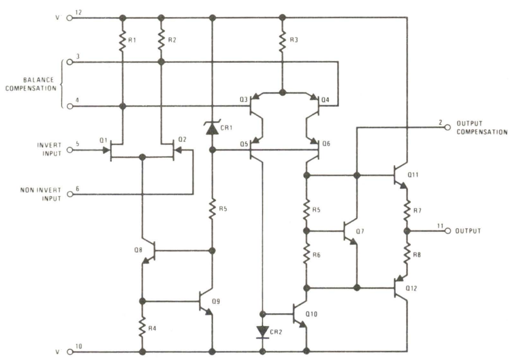
features

- High slew rate 500 V/μs
- High bandwidth 70 MHz
- High input impedance $10^{12}\Omega$
- Low input bias current 20 pA max
- Offset null with single pot
- Low input offset voltage 2 mV max
- No compensation for gains above 50

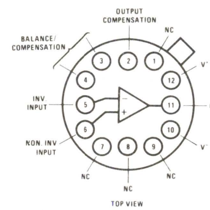
The LH0032's wide bandwidth, high input impedance and high output capacity make it an ideal choice for applications such as summing amplifiers in high speed D to A's, buffers in data acquisition systems, and sample and hold circuits. Additional applications include high speed integrators and video amplifiers. The LH0032 is guaranteed over the temperature range –55°C to +125°C and the LH0032C is guaranteed from –25°C to +85°C.

For information on other National operational amplifiers, see listing on last page.

schematic and connection diagrams



Metal Can Package

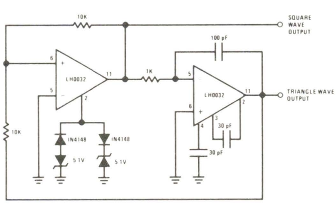


Note: For heat sink use thermalloy 2240 series or Wakefield 215-XX series.

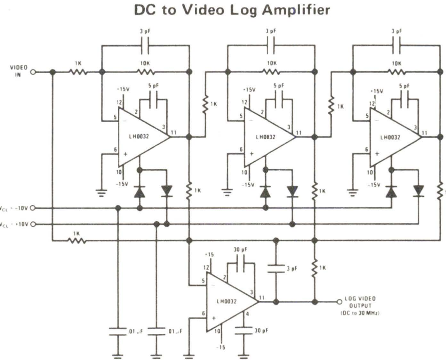
Order Number LH0032G or LH0032CG
See Package 6

typical applications

1 MHz Function Generator



DC to Video Log Amplifier



Note: All diodes must be low stored charge, high speed. Decouple power supplies at each amp with 0.01μF ceramic discs.

absolute maximum ratings

Supply Voltage		±18V
Input Voltage		$\pm V_S$
Differential Input Voltage		±30V
Power Dissipation		See curve
Operating Temperature Range	LH0032	−55°C to +125°C
	LH0032C	−25°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0032			LH0032C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$V_S = \pm 15V$, $R_S \leq 100k$, $T_A = 25°C$		2	5		5	15	mV
	$V_S = \pm 15V$, $R_S \leq 100k$			10			20	mV
Average Offset Voltage Drift	$R_S \leq 100k$		25			25		μV/°C
Input Bias Current	$T_A = 25°C$		10	100		25	200	pA
				50			15.0	nA
Input Offset Current	$T_A = 25°C$		5	25		10	50	pA
				25			5	nA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$, f = 1 kHz $R_L = 1\ k\Omega$, $T_A = 25°C$	60	70		60	70		dB
	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$, f = 1 kHz $R_L = 1\ k\Omega$	57			57			dB
Input Voltage Range	$V_S = \pm 15V$	±10	±12		±10	±12		V
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 1\ k\Omega$	±10	±13.5		±10	±13		V
Power Supply Rejection Ratio	$V_S = \pm 15V$, $\Delta V_S = \pm 10V$	50	60		50	60		dB
Common Mode Rejection Ratio	$V_S = \pm 15V$, $\Delta V_{IN} = 10V$	50	60		50	60		dB
Supply Current	$V_S = \pm 15V$, $T_A = 25°C$		18	20		20	22	mA

ac electrical characteristics (Note 2)

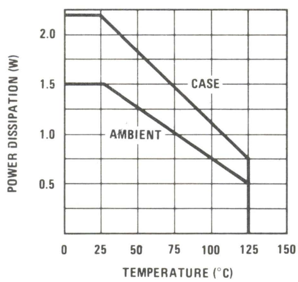
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Slew Rate	$A_V = +1$, $\Delta V_{IN} = 20V$	350	500		V/μs
Settling Time to 1% of Final Value	$A_V = -1$, $\Delta V_{IN} = 20V$		100		ns
Settling Time to 0.1% of Final Value	$A_V = -1$, $\Delta V_{IN} = 20V$		300		ns
Small Signal Rise Time	$A_V = +1$, $\Delta V_{IN} = 1V$		8	20	ns
Small Signal Delay Time	$A_V = +1$, $\Delta V_{IN} = 1V$		10	25	ns

Note 1: These specifications apply for $\pm 5V \leq V_S \leq \pm 18V$ and −55°C to +125°C for the LH0032 and −25°C to +85°C for the LH0032C.

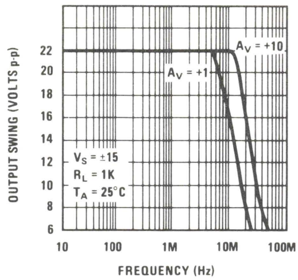
Note 2: These specifications apply for $V_S = \pm 15V$, $R_L = 1\ k\Omega$ and $T_A = 25°C$.

typical performance characteristics

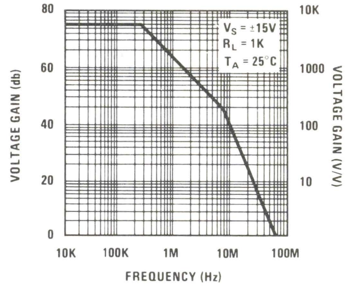
Maximum Power Dissipation



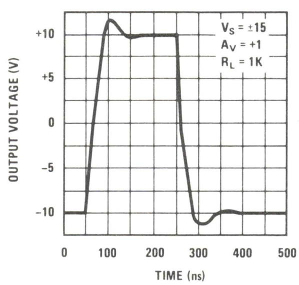
Large Signal Frequency Response



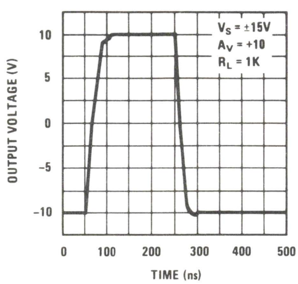
Open Loop Frequency Response



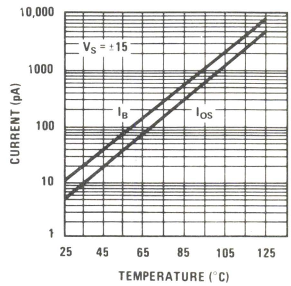
Large Signal Pulse Response



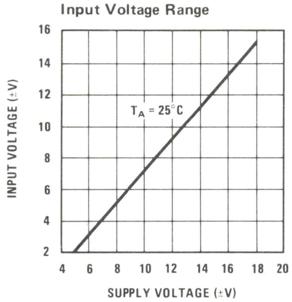
Large Signal Pulse Response



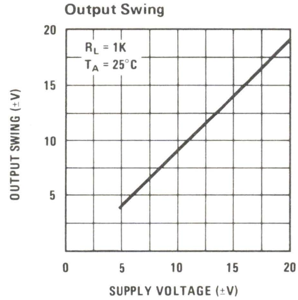
Input Bias and Offset Current vs Temperature



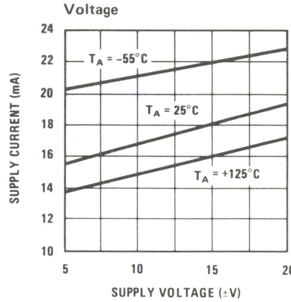
Input Voltage Range



Output Swing

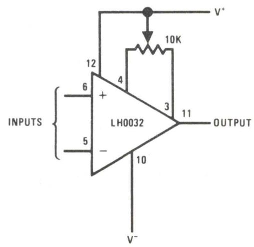


Supply Current vs Supply Voltage

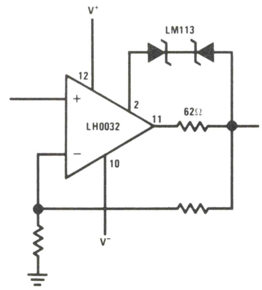


auxiliary circuits

Offset Null

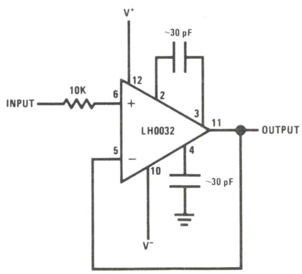


Output Short Circuit Protection

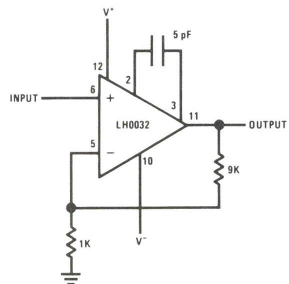


typical applications (con't)

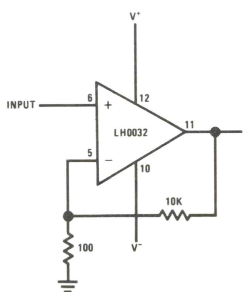
Unity Gain Amplifier



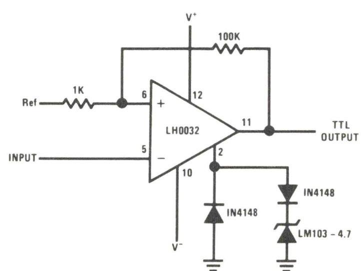
10X Buffer Amplifier



100X Buffer Amplifier

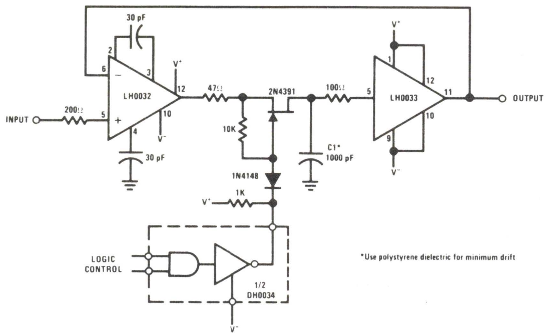


High Impedance, High Speed Comparator

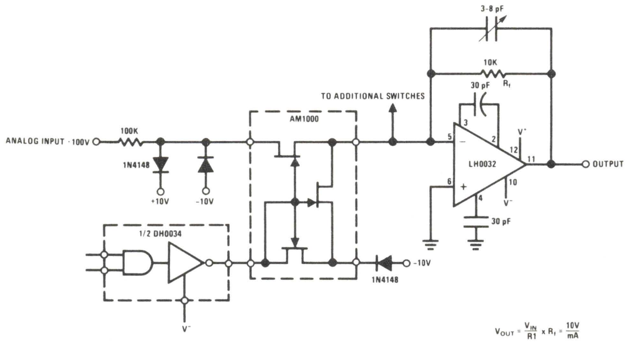


typical applications (con't)

High Speed Sample and Hold



Current Mode Multiplexer



applications information

Power Supply Decoupling

The LH0032/LH0032C like most high speed circuits is sensitive to layout and stray capacitance. Power supplies should be by-passed as near to Pins 10 and 12 as practicable with low inductance capacitors such as 0.01 μF disc ceramics. Compensation components should also be located close to the appropriate pins to minimize stray reactances.

Input Capacitance

The input capacitance to the LH0032/LH0032C is typically 5 pF and thus may form a significant time constant with high value resistors. For optimum performance, the input capacitance to the inverting input should be compensated by a small capacitor across the feedback resistor. The value is strongly dependent on layout and closed loop gain, but will typically be in the neighborhood of several picofarads.

In the non-inverting configuration, it may be advantageous to bootstrap the case and/or a guard conductor to the inverting input. This serves both to divert leakage currents away from the non-inverting input and to reduce the effective input capacitance. A unity gain follower so treated will have an input capacitance under a picofarad.

Heat Sinking

While the LH0032/LH0032C is specified for operation without any explicit head sink, internal power dissipation does cause a significant temperature rise. Improved bias current performance can thus be obtained by limiting this temperature rise with a small head sink such as the Thermalloy No. 2241 or equivalent. The case of the device has no internal connection, so it may be electrically connected to the sink if this is advantageous. Be aware, however, that this will affect the stray capacitances to all pins and may thus require adjustment of circuit compensation values.

Operational Amplifiers

LH0033/LH0033C, LH0063/LH0063C
fast and damn fast buffer amplifiers

general description

The LH0033/LH0033C and LH0063/LH0063C are high speed, FET input, voltage follower/buffers designed to provide high current drive at frequencies from DC to over 100 MHz. The LH0033/LH0033C will provide ±10 mA into 1 kΩ loads (±100 mA peak) at slew rates of 1500V/µs. The LH0063/LH0063C will provide ±250 mA into 50Ω loads (±500 mA peak) at slew rates of up to 6000V/µs. In addition, both exhibit excellent phase linearity up to 20 MHz.

Both are intended to fulfill a wide range of buffer applications such as high speed line drivers, video impedance transformation, nuclear instrumentation amplifiers, op amp isolation buffer for driving reactive loads and high impedance input buffers for high speed A to D's and comparators. In addition, the LH0063/LH0063C can continuously drive 50Ω coaxial cables or be used as a diddle yoke driver for high resolution CRT displays. For additional applications information, see AN-48.

advantages

- Only +10V supply needed for 5 V_{P-P} video out
- Speed does not degrade system performance
- Wide data rate range for phase encoded systems
- Output drive adequate for most loads
- Single pre-calibrated package

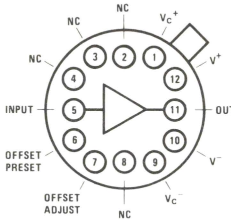
features

■ Damn fast (LH0063)	6000V/µs
■ Wide range single or dual supply operation	
■ Wide power bandwidth	DC to 100 MHz
■ High output drive	±10V with 50Ω load
■ Low phase non-linearity	2 degrees
■ Fast rise times	2 ns
■ High current gain	120 dB
■ High input resistance	10^{10} Ω

These devices are constructed using specially selected junction FET's and active laser trimming to achieve guaranteed performance specifications. The LH0033 and LH0063 are specified for operation from −55°C to +125°C; whereas, the LH0033C and LH0063C are specified from −25°C to +85°C. The LH0033/LH0033C is available in a 1.5W metal TO-8 package and a special 1/2 x 1 inch 8 pin ceramic dual-in-line package while the LH0063/LH0063C is available in a 5W 8-pin TO-3 package.

connection diagrams

LH0033/LH0033C
Metal Can Package

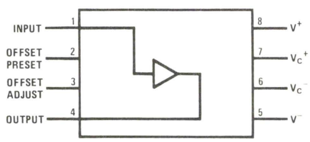


TOP VIEW

CASE IS ELECTRICALLY ISOLATED

Order Number LH0033G or LH0033CG
See Package 6

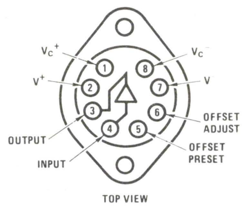
LH0033/LH0033C
Dual-In-Line Package



TOP VIEW

Order Number LH0033J or LH0033CJ
See Package 15

LH0063/LH0063C
Metal Can Package



TOP VIEW

CASE IS ELECTRICALLY ISOLATED

Order Number LH0063K or LH0063CK
See Package 19

absolute maximum ratings

Supply Voltage ($V^+ - V^-$)	40V
Maximum Power Dissipation (See Curves)	
LH0063/LH0063C	5W
LH0033/LH0033C	1.5W
Maximum Junction Temperature	175°C
Input Voltage	Equal to Supplies
Continuous Output Current	
LH0063/LH0063C	±250 mA
LH0033/LH0033C	±100 mA
Peak Output Current	
LH0063/LH0063C	±500 mA
LH0033/LH0033C	±250 mA
Operating Temperature Range	
LH0033 and LH0063	−55°C to +125°C
LH0033C and LH0063C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics LH0033/LH0033C: (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Offset Voltage	R_S = 100 kΩ, T_C = 25°C R_S = 100 kΩ		5	10 15		12	20 25	mV mV
Average Temperature Coefficient of Offset Voltage	R_S = 100 kΩ, −55°C ≤ T_C ≤ 125°C		25			25		μV/°C
Input Bias Current	T_C = 25°C		.05	.1 10		.05	.15 5	nA nA
Voltage Gain	V_{IN} = 1Vrms, f = 1 kHz, R_L = 1 kΩ, R_S = 100 kΩ	.97	.98	1	.96	.98	1	V/V
Input Impedance	V_{IN} = 1Vrms, f = 1 kHz, R_L = 1 kΩ	10^{10}	10^{11}		10^{10}	10^{11}		Ω
Output Impedance	V_{IN} = 1Vrms, f = 1 kHz, R_S = 100 kΩ, R_L = 1 kΩ		6	10		6	10	Ω
Output Voltage Swing	R_L = 1 kΩ, R_L = 100Ω, T_C = 25°C V_S = ±5V, R_L = 1 kΩ	±12 ±9	±13 6		±12 ±9	±13 6		V V V_{P-P}
Supply Current	V_{IN} = 0V, V_S = ±15V V_S = ±5V		20 18	22		21 18	24	mA mA
Power Consumption	V_{IN} = 0V, V_S = ±15V V_S = ±5V		600 180	660		630 180	720	mW mW

ac electrical characteristics

LH0033/LH0033C (T_C = 25°C, V_S = ±15V, R_S = 50Ω, R_L = 1 kΩ)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	V_{IN} = ±10V	1000	1500		1000	1400		V/μs
Bandwidth	V_{IN} = 1Vrms		100			100		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	ΔV_{IN} = 0.5V		2.9			3.2		ns
Propagation Delay	ΔV_{IN} = 0.5V		1.2			1.5		ns
Harmonic Distortion			<0.1			<0.1		%

Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, −15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, −15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of −55°C ≤ T_C ≤ +125°C for the LH0033 and LH0063; and −25°C ≤ T_C ≤ +85°C for the LH0033C and LH0063C. Typical values shown are for T_C = 25°C.

dc electrical characteristics LH0063/LH0063C (Note 1)

PARAMETER	CONDITIONS	LIMITS LH0063 MIN	LH0063 TYP	LH0063 MAX	LH0063C MIN	LH0063C TYP	LH0063C MAX	UNITS
Output Offset Voltage	$R_S \leq 100\ k\Omega$, $T_C = 25°C$		10	25		10	50	mV
	$R_S \leq 100\ k\Omega$			100			100	mV
Average Temperature Coefficient of Output Offset Voltage	$R_S \leq 100\ k\Omega$		300			300		$\mu V/°C$
Input Bias Current	$T_C = 25°C$		.1	.2		.1	.2	nA
				10			5	nA
Voltage Gain	$V_{IN} = \pm 10V$, $R_S \leq 100\ k\Omega$, $R_L = 1\ k\Omega$	.96	.98	1	.96	.98	1	V/V
Voltage Gain	$V_{IN} = \pm 10V$, $R_S \leq 100\ k\Omega$, $R_L = 50\Omega$	.94	.96	.98	.94	.96	.98	V/V
Input Resistance		10^{10}	10^{11}		10^{10}	10^{11}		Ω
Input Capacitance	Case Shorted to Output		8			8		pF
Output Impedance	$V_{OUT} = \pm 10V$, $R_S = 100\ k\Omega$		1	4		1	4	Ω
Output Current Swing	$V_{IN} = \pm 10V$, $R_S \leq 100\ k\Omega$	.2	.25		.2	.25		Amps
Output Voltage Swing	$R_L = 50\Omega$	±10	±13		±10	±13		V
Output Voltage Swing	$V_S = \pm 5V$, $R_L = 50\Omega$, $T_C = 25°C$	5	7		5	7		V_{P-P}
Supply Current	$T_C = 25°C$, $R_L = \infty$, $V_S = \pm 15V$		60	75		60	80	mA
Supply Current	$V_S = \pm 5V$		50			50		mA
Power Consumption	$T_C = 25°C$, $R_L = \infty$, $V_S = \pm 15V$		1.80	2.25		1.80	2.40	W
Power Consumption	$V_S = \pm 5V$		500			500		mW

ac electrical characteristics

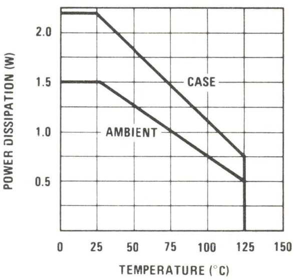
LH0063/LH0063C: ($T_C = 25°C$, $V_S = \pm 15V$, $R_S = 50\Omega$, $R_L = 50\Omega$)

PARAMETER	CONDITIONS	LIMITS LH0063 MIN	LH0063 TYP	LH0063 MAX	LH0063C MIN	LH0063C TYP	LH0063C MAX	UNITS
Slew Rate	$R_L = 1\ k\Omega$, $V_{IN} = \pm 10V$		6000			6000		V/µs
Slew Rate	$R_L = 50\Omega$, $V_{IN} = \pm 10V$, $T_C = 25°C$	2000	4000		2000	4000		V/µs
Bandwidth	$V_{IN} = 1$ Vrms		200			200		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	$\Delta V_{IN} = .5V$		1.6			1.9		ns
Propagation Delay	$\Delta V_{IN} = .5V$		1.9			2.1		ns
Harmonic Distortion			<0.1			<0.1		%

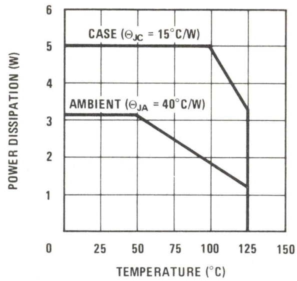
Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, −15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, −15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of $-55°C \leq T_C \leq +125°C$ for the LH0033 and LH0063; and $-25°C \leq T_C \leq +85°C$ for the LH0033C and LH0063C. Typical values shown are for $T_C = 25°C$.

typical performance characteristics

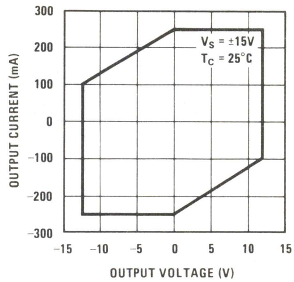
LH0033 Power Dissipation



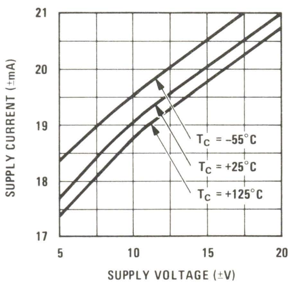
LH0063 Power Dissipation



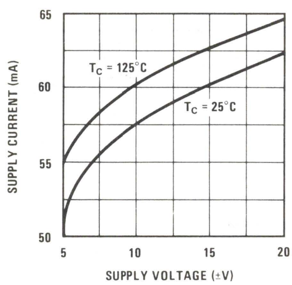
LH0063 DC Safe Operating Area



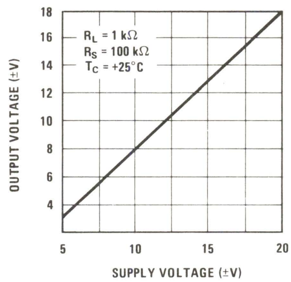
LH0033 Supply Current vs Supply Voltage



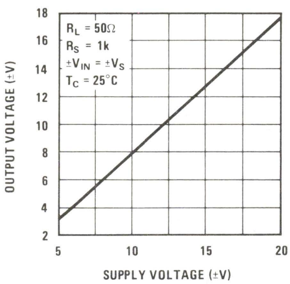
LH0063 Supply Current vs Supply Voltage



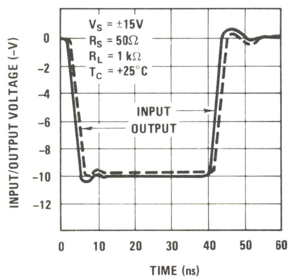
LH0033 Output Voltage vs Supply Voltage



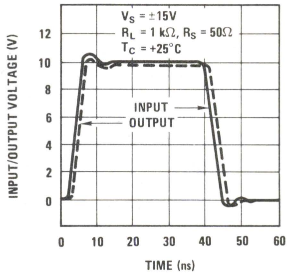
LH0063 Output Voltage vs Supply Voltage



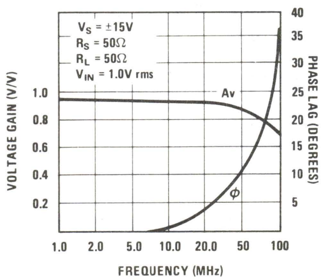
LH0033 Negative Pulse Response



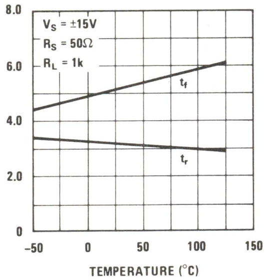
LH0033 Positive Pulse Response



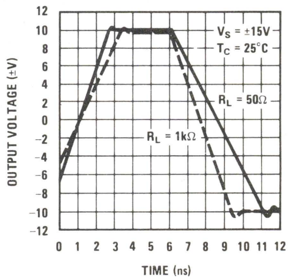
LH0033 Frequency Response



LH0033 Rise and Fall Time vs Temperature

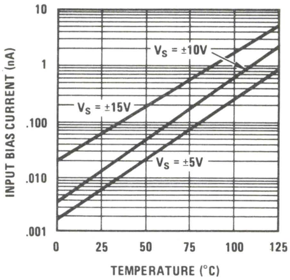


LH0063 Large Signal Pulse Response

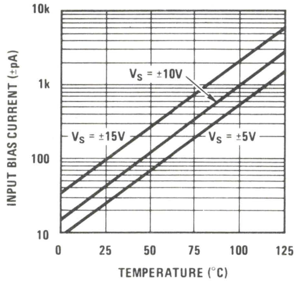


typical performance characteristics (con't)

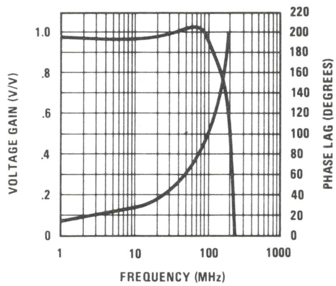
LH0033 Input Bias Current vs Temperature



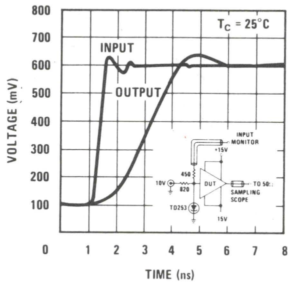
LH0063 Input Current



LH0063 Frequency Response



LH0063 Small Signal Rise Time



application hints

Recommended Layout Precautions: RF/video printed circuit board layout rules should be followed when using the LH0033 and LH0063 since they will provide power gain to frequencies over 100 MHz. Ground planes are recommended and power supplies should be decoupled at each device with low inductance 0.1μF disc capacitors. In addition, ground plane shielding may be extended to the metal case of the device since it is electrically isolated from internal circuitry. Alternatively the case should be connected to the output to minimize input capacitance.

Offset Voltage Adjustment: Both the LH0033's and LH0063's offset voltages have been actively trimmed by laser to meet guaranteed specifications when the offset preset pin is shorted to the offset adjust pin. This pre-calibration allows the devices to be used in most DC or AC applications without individually offset nulling each device. If offset null is desirable, it is simply obtained by leaving the offset preset pin open and connecting a trim pot of 100Ω for the LH0033 or 1 kΩ for the LH0063 between the offset adjust pin and V^- as illustrated in Figures 1 and 2.

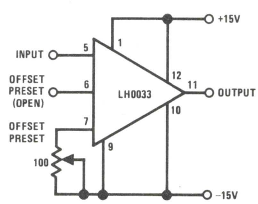


FIGURE 1. Offset Zero Adjust for LH0033 (Pin nos. shown for TO-8)

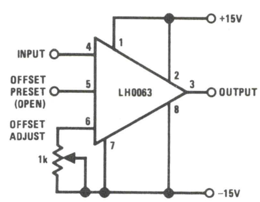


FIGURE 2. Offset Zero Adjust for LH0063

application hints (con't)

Operation from Single or Asymmetrical Power Supplies: Both device types may be readily used in applications where symmetrical supplies are unavailable or not desirable. A typical application might be an interface to a MOS shift register where $V^+ = +5V$ and $V^- = -12V$. In this case, an apparent output offset occurs due to the device's voltage gain of less than unity. This additional output offset error may be predicted by:

$$\Delta V_O \cong (1 - A_V)\frac{(V^+ - V^-)}{2} = .005\,(V^+ - V^-)$$

where:

A_V = No load voltage gain, typically .99

V^+ = Positive supply voltage

V^- = Negative supply voltage

For the above example, ΔV_O would be −35 mV. This may be adjusted to zero as described in Section 2. For AC coupled applications, no additional offset occurs if the DC input is properly biased as illustrated in the "typical applications" section.

Short Circuit Protection: In order to optimize transient response and output swing, output current limit has been omitted from the LH0033 and LH0063. Short circuit protection may be added by inserting appropriate value resistors between V^+ and $V_C{}^+$ pins and V^- and $V_C{}^-$ pins as illustrated in Figures 3 and 4. Resistor values may be predicted by:

$$R_{LIM} \cong \frac{V^+}{I_{SC}} = \frac{V^-}{I_{SC}}$$

where: $I_{SC} \leq 100$ mA for LH0033

$I_{SC} \leq 250$ mA for LH0063

The inclusion of limiting resistors in the collectors of the output transistors reduces output voltage swing. Decoupling $V_C{}^+$ and $V_C{}^-$ pins with capacitors to ground will retain full output swing for transient pulses. Alternate active current limit techniques that retain full DC output swing are shown in Figures 5, 6 and 7. In Figures 5 and 6, the current sources are saturated during normal operation thus apply full supply voltage to the V_C pins. Under fault conditions, the voltage decreases as required by the overload. For Figure 5:

$$R_{LIM} = \frac{V_{BE}}{I_{SC}} = \frac{.6V}{60\text{ mA}} = 10\Omega$$

In Figure 6, quad transistor arrays are used to minimize can count and:

$$R_{LIM} = \frac{V_{BE}}{1/3\,(I_{SC})} = \frac{.6V}{1/3\,(200\text{ mA})} = 8.2\Omega$$

Foldback current has been added in Figure 7 to minimize power dissipation under fault conditions. Output transistor collector current is sensed and input stage voltage is reduced as required by fault load. Resistor values may be predicted by:

$$R_{LIM} \cong \frac{V_{BE}}{I_{KNEE}}$$

$$R_{FB} \cong \frac{(V_S \times R_1)}{V_{BE} - (R_{LIMIT} \times I_{SHORT\ CIRCUIT})}$$

Thus for the LH0033 with I_{KNEE} = 60 mA and I_{SHORT} = 10 mA, R_{LIM} = 10Ω and R_{FB} = 30 kΩ. For the LH0063 with I_{KNEE} = 200 mA and I_{SHORT} = 50 mA, R_{LIM} = 3Ω and R_{FB} = 33 kΩ.

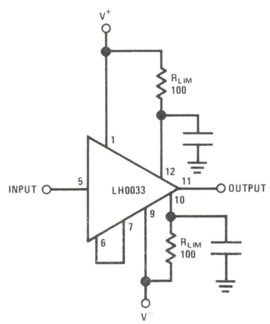


FIGURE 3. LH0033 Using Resistor Current Limiting

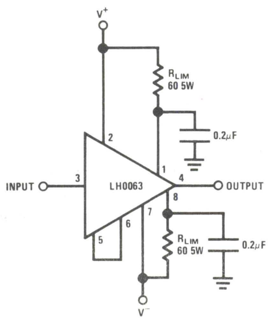


FIGURE 4. LH0063 Using Resistor Current Limiting

application hints (con't)

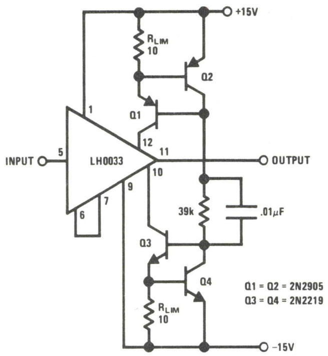


FIGURE 5. LH0033 Current Limiting Using Current Sources

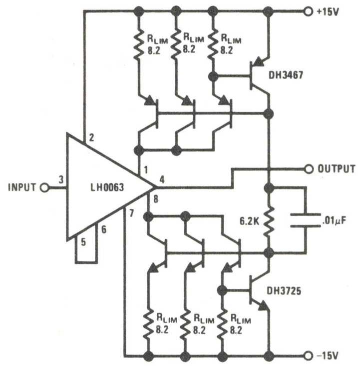


FIGURE 6. LH0063 Current Limiting Using Current Sources

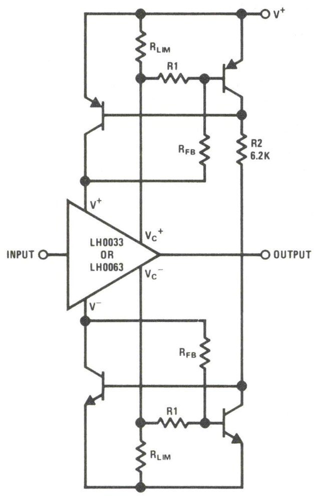


FIGURE 7. Foldback Current Limit

Capacitive Loading: Both the LH0033 and LH0063 are designed to drive capacitive loads such as coaxial cables in excess of several thousand picofarads without susceptibility to oscillation. However, peak current resulting from $(C \times d_V/d_t)$ should be limited below absolute maximum peak current ratings for the devices.

Thus for the LH0033:

$$\left(\frac{\Delta V_{IN}}{\Delta T}\right) \times C_L \leq I_{OUT} \leq \pm 250 \text{ mA}$$

and for the LH0063:

$$\left(\frac{\Delta V_{IN}}{\Delta T}\right) \times C_L \leq I_{OUT} \leq \pm 500 \text{ mA}$$

Peak current limiting may be accomplished by controlling input large signal rise time, inserting 20 to 100Ω resistors between V^+ and $V_C{}^+$ pins and V^- and $V_C{}^-$ pins, using active current limit as described in Section 4, Figures 5, 6 and 7, or inserting a small value resistor in series with the output.

application hints (con't)

In addition, power dissipation resulting from driving capacitative loads plus standby power should be kept below total package power rating:

$$P_{\substack{diss\\pkg}} \geq P_{DC} + P_{AC}$$

$$P_{\substack{diss\\pkg}} \geq (V^+ - V^-) \times I_S + P_{AC}$$

$$P_{AC} \cong (V_{P\text{-}P})^2 \times f \times C_L$$

where $V_{P\text{-}P}$ = Peak-to-peak output voltage swing

f = frequency

C_L = Load Capacitance

Operation Within an Op Amp Loop: Both devices may be used as a current booster or isolation buffer within a closed loop with op amps such as LH0032, LH0062, or LM118. An isolation resistor of 47Ω should be used between the op amp output and the input of LH0033. The wide bandwidths and high slew rates of the LH0033 and LH0063 assure that the loop has the characteristics of the op amp and that additional rolloff is not required.

Hardware: In order to utilize the full drive capabilities of both devices, each should be mounted with a heat sink particularly for extended temperature operation. The cases of both are isolated from the circuit and may be connected to system chassis. Heat sinks are commercially available at low cost; the following or their equivalents are recommended:

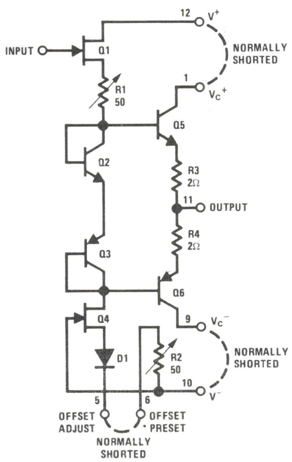
LH0033G (TO-8 pkg):	Thermalloy #2240A Wakefield #215-CB
LH0063K (TO-3 pkg):	IERC #LAIC3B4V

Mounting and test sockets are available from:

LH0033G (TO-8 pkg):	Barnes Corp. #MGX-12
LH0063K (TO-3 pkg):	Keystone Elect. (N.Y.) #4626 or #4627

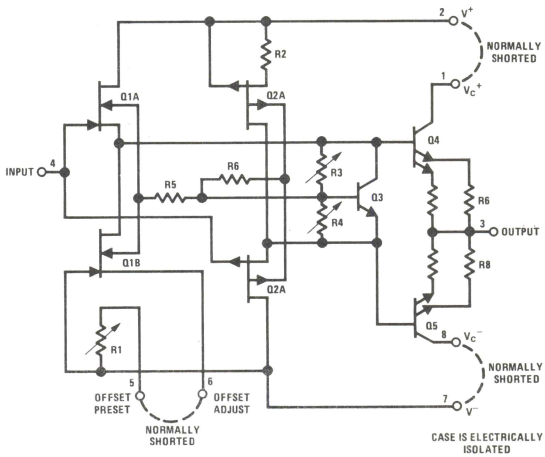
schematic diagrams

LH0033/LH0033C



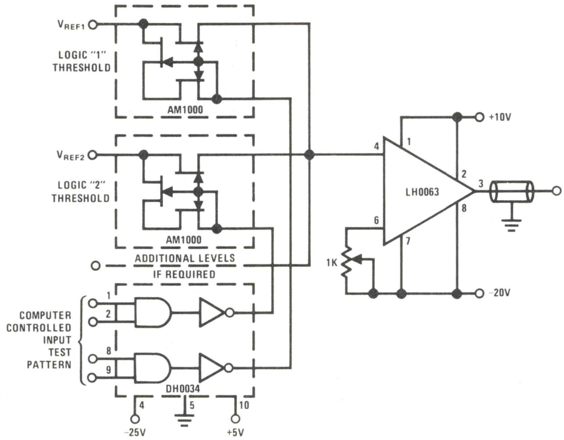
PIN NUMBERS SHOWN FOR TO-8 ("G") PACKAGE.

LH0063/LH0063C

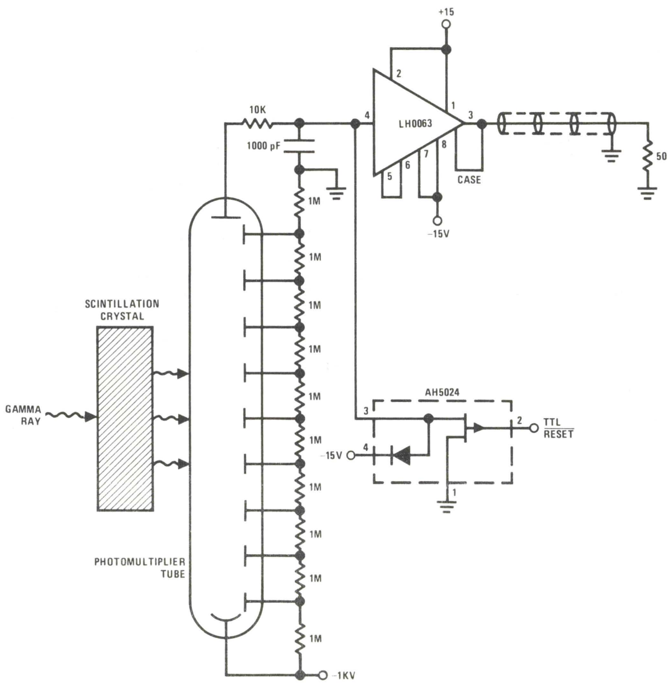


typical applications

High Speed Automatic Test Equipment Forcing Function Generator

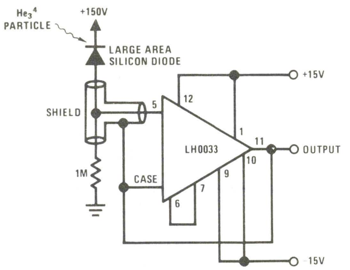


Gamma Ray Pulse Integrator

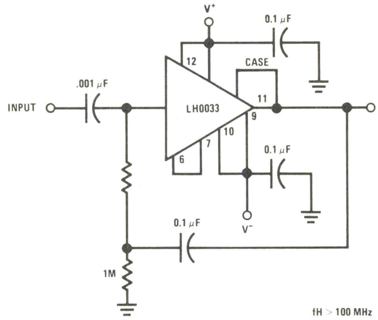


typical applications (con't)

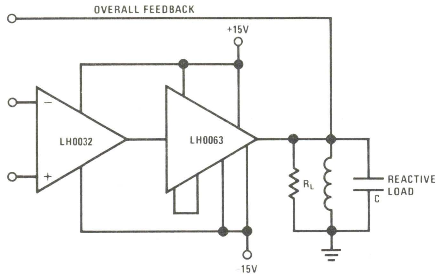
Nuclear Particle Detector



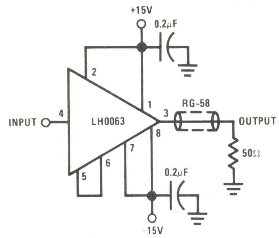
High Input Impedance AC Coupled Amplifier



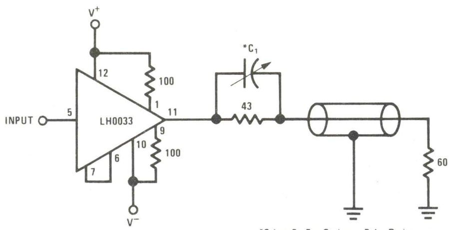
Isolation Buffer



Coaxial Cable Driver

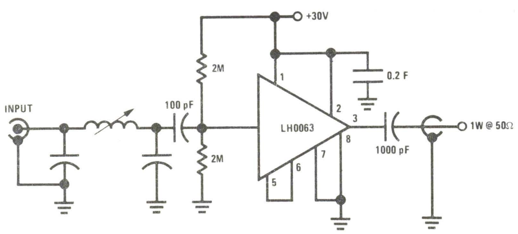


Coaxial Cable Driver



*Select C_1 For Optimum Pulse Resistance

1W CW Final Amplifier

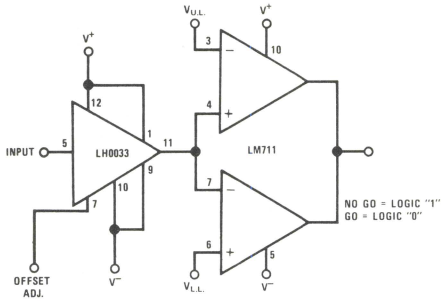


LH0033/LH0033C, LH0063/LH0063C

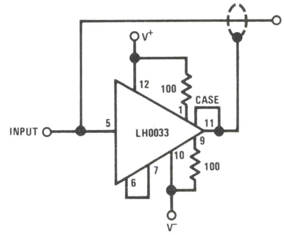
2

typical applications (con't)

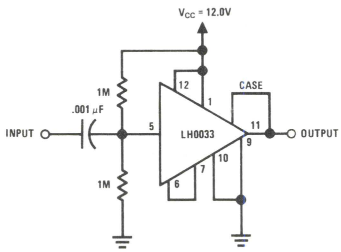
High Input Impedance Comparator With Offset Adjust



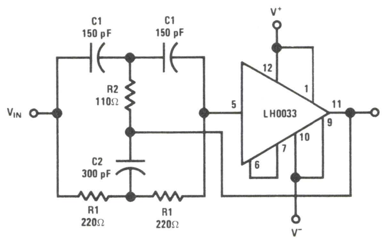
Instrumentation Shield/Line Driver



Single Supply AC Amplifier



4.5 MHz Notch Filter

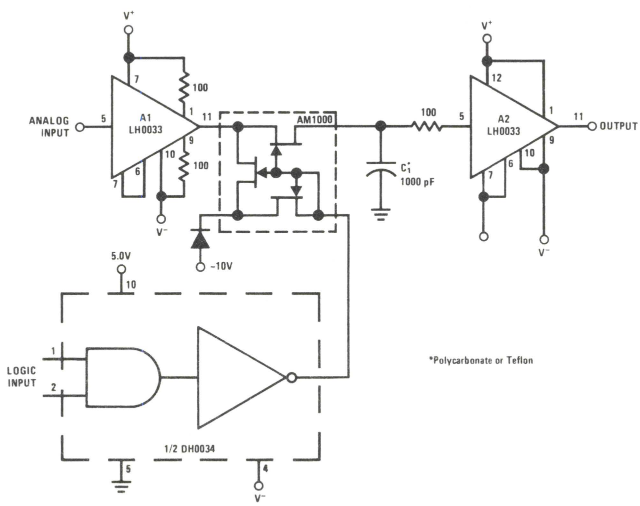


$f_O = \frac{1}{2\pi R1C1}$

R1 = 2 R2

$C1 = \frac{C2}{2}$

High Speed Sample & Hold



*Polycarbonate or Teflon

LH0061/LH0061C 0.5 amp wide band operational amplifier

general description

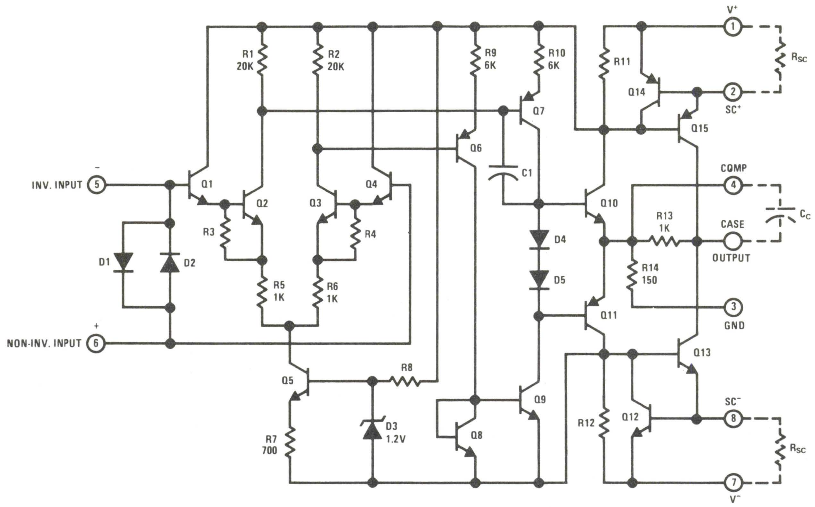
The LH0061/LH0061C is a wide band, high speed, operational amplifier capable of supplying currents in excess of 0.5 ampere at voltage levels of ±12V. Output short circuit protection is set by external resistors, and compensation is accomplished with a single external capacitor. With a suitable heat sink the device is rated at 20 Watts.

The wide bandwidth and high output power capabilities of the LH0061/LH0061C make it ideal for such applications as AC servos, deflection yoke drivers, capstan drivers, and audio amplifiers. The LH0061 is guaranteed over the temperature range −55°C to +125°C; whereas, the LH0061C is guaranteed from −25°C to +85°C.

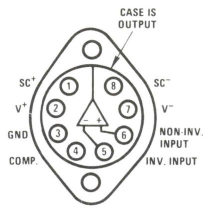
features

■ Output current	0.5 Amp
■ Wide large signal bandwidth	1 MHz
■ High slew rate	75 V/μs
■ Low standby power	240 mW
■ Low input current	300 nA Max

schematic and connection diagrams



TO-3 Package



TOP VIEW

Order Numbers:

LH0061K (−55°C to +125°C)
LH0061CK (−25°C to +85°C)
See Package 19

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation	See Curve
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Peak Output Current	2A
Output Short Circuit Duration (Note 4)	Continuous
Operating Temperature Range LH0061	−55°C to +125°C
LH0061C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LIMITS LH0061 MIN	TYP	MAX	LH0061C MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S \le 10\ k\Omega$, $T_C = 25°C$, $V_S = \pm15V$		1.0	4.0		3.0	10	mV
	$R_S \le 10\ k\Omega$, $V_S = \pm15V$			6.0			15	mV
Voltage Drift with Temperature	$R_S \le 10\ k\Omega$		5			5		μV/°C
Offset Voltage Change with Output Power			5			5		μV/watt
Input Offset Current	$T_C = 25°C$		30	100		50	200	nA
				300			500	nA
Offset Current Drift with Temperature			1			1		nA/°C
Input Bias Current	$T_C = 25°C$		100	300		200	500	nA
				1.0			1.0	μA
Input Resistance	$T_C = 25°C$	0.3	1.0		0.3	1.0		MΩ
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \le 10\ k\Omega$, $\Delta V_{CM} = \pm10V$	70	90		60	80		dB
Input Voltage Range	$V_S = \pm15V$	±11			±11			V
Power Supply Rejection Ratio	$R_S \le 10\ k\Omega$, $\Delta V_S = \pm10V$	70	80		50	70		dB
Voltage Gain	$V_S = \pm15V$, $V_O = \pm10V$ $R_L = 1\ k\Omega$, $T_C = 25°C$	50	100		25	50		V/mV
	$V_S = \pm15V$, $V_O = \pm10V$ $R_L = 20\Omega$	5			2.5			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 20\Omega$	±10	±12		±10	±12		V
Output Short Circuit Current	$V_S = \pm15V$, $T_C = 25°C$, $R_{SC} = 1.0\Omega$		600			600		mA
Power Supply Current	$V_S = \pm15V$, $V_{OUT} = 0$		7	10		10	15	mA
Power Consumption	$V_S = \pm15V$, $V_{OUT} = 0$		210	300		300	450	mW

ac electrical characteristics ($T_C = 25°C$, $V_S = \pm15V$, $C_C = 3000$ pF)

PARAMETER	CONDITIONS	LH0061 MIN	TYP	MAX	LH0061C MIN	TYP	MAX	UNITS
Slew Rate	$A_V = +1$, $R_L = 100\Omega$	50	70		50	70		V/μs
Power Bandwidth	$R_L = 100\Omega$		1			1		MHz
Small Signal Transient Response			30			30		ns
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{IN} = 10V$, $A_V = +1$		0.8			0.8		μs
Overload Recovery Time			1			1		μs
Harmonic Distortion	f = 1 kHz, $P_O = 0.5W$		0.2			0.2		%

Note 1: Specifications apply for $\pm5V \le V_S \le \pm18V$, $C_C = 3000$ pF, and $-55°C \le T_C \le +125°C$ for the LH0061K and $-25°C \le T_C \le +85°C$ for the LH0061CK. Typical values are for $T_C = 25°C$.

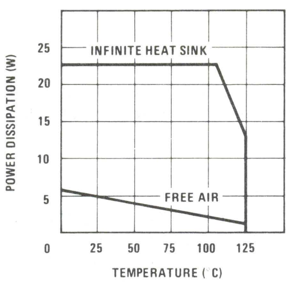
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Excessive current will flow if a differential voltage in excess of 1V is applied between the inputs without limiting resistors.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

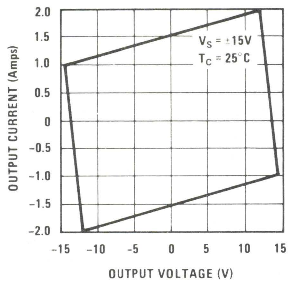
Note 4: Rating applies as long as package power rating is not exceeded.

typical performance characteristics

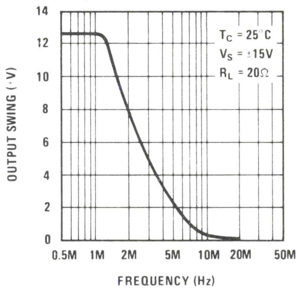
Power Derating



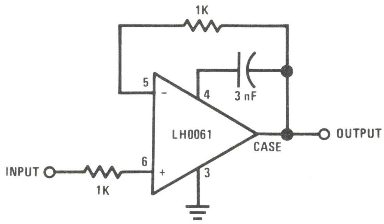
Safe Operating Area



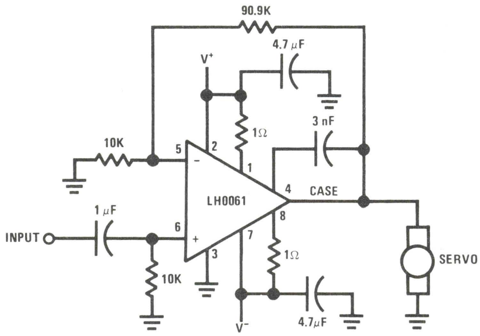
Large Signal Frequency Response



typical applications



Unity Gain Driver



AC Servo Amplifier

LH0062/LH0062C high speed FET op amp

general description

The LH0062/LH0062C is a precision, high speed FET input operational amplifier with more than an order of magnitude improvement in slew rate and bandwidth over conventional FET IC op amps. In addition it features very closely matched input characteristics, very high input impedance, and ultra low input currents with no compromise in noise, common mode rejection ratio or open loop gain. The device has internal unity gain frequency compensation, thus assuring stability in all normal applications. This considerably simplifies its application, since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 120 V/μs and almost double the bandwidth. (See LB-2, LB-14, and LB-17 for discussions of the application of feed-forward techniques). Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μs. In addition it is free of latch-up and may be simply offset nulled with negligible effect on offset drift or CMRR.

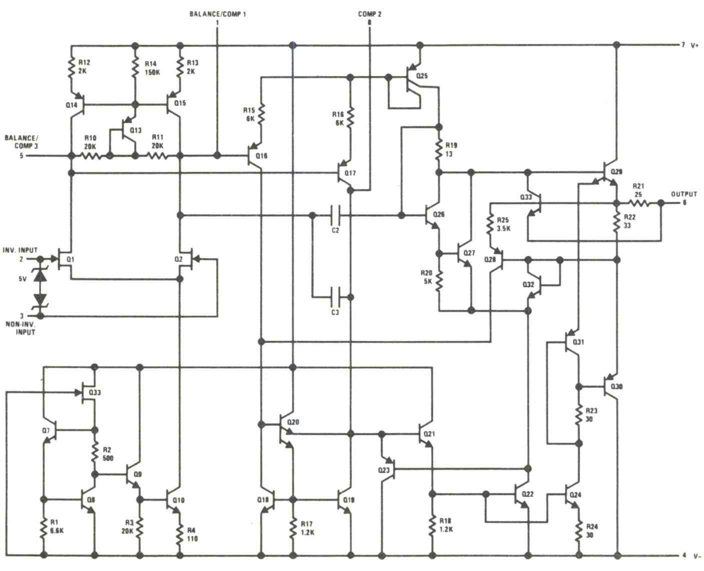
The LH0062 is also available on special order with offset voltage internally laser nulled and ultra low (0.1 pA) offset current.

The LH0062 is designed for applications requiring wide bandwidth, high slew rate and fast settling time while at the same time demanding the high input impedance and low input currents characteristic of FET inputs. Thus it is particularly suited for such applications as video amplifiers, sample/hold circuits, high speed integrators, and buffers for A/D conversion and multiplex system. The LH0062 is specified for the full military temperature range of −55° to +125°C while the LH0062C is specified to operate over a −25°C to +85°C temperature range.

features

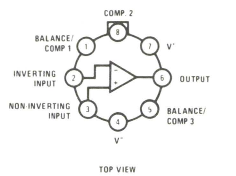
■ High slew rate	70 V/μs
■ Wide bandwidth	15 MHz
■ Settling time (0.1%)	1μs
■ Low input offset voltage	2 mV
■ Low input offset current	1 pA
■ Wide supply range	±5V to ±20V
■ Internal 6 dB/octave frequency compensation	
■ Pin compatible with std IC op amps (TO-5 pkg)	

schematic and connection diagrams*



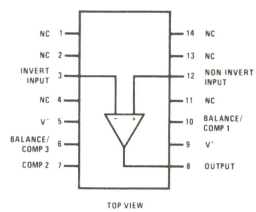
*Pin Numbers Shown for TO-5 Package

Metal Can Package



Order Number LH0062H or LH0062CH See Package 11

Dual-In-Line Package



Order Number LH0062D or LH0062CD See Package 1

absolute maximum ratings

Supply Voltage	±20V	Operating Temperature	
Power Dissipation (see graph)	500 mW	LH0062,	−55°C to +125°C
Input Voltage (Note 1)	±15V	LH0062C,	−25°C to +85°C
Differential Input Voltage (Note 2)	±30V	Storage Temperature Range	−65°C to +150°C
Short Circuit Duration	Continuous	Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0062			LH0062C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 100\ k\Omega$; $T_A = 25°C$		2	5		10	15	mV
	$R_S \leq 100\ k\Omega$			7			20	mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\ k\Omega$		5	25		10	35	µV/°C
Offset Voltage Drift with Time			4			5		µV/week
Input Offset Current	$T_A = 25°C$		0.2	2		1	5	pA
				500			200	pA
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C		
Offset Current Drift with Time			0.1			0.1		pA/week
Input Bias Current	$T_A = 25°C$		5	25		10	65	pA
				5			2	nA
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C		
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4			4		pF
Input Voltage Range	$V_S = \pm15V$	±10	±12		±10	±12		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$, $V_{IN} = \pm10V$	80	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$, $\pm5V \leq V_S \leq \pm15V$	80	90		70	90		dB
Large Signal Voltage Gain	$R_L = 2\ k\Omega$, $V_{OUT} = \pm10V$, $T_A = 25°C$, $V_S = \pm15V$	50	200		25	160		V/mV
	$R_L = 2\ k\Omega$, $V_{OUT} = \pm10V$, $V_S = \pm15V$	25			25			V/mV
Output Voltage Swing	$R_L = 2\ k\Omega$, $T_A = 25°C$, $V_S = \pm15V$	±12	±13		±12	±13		V
	$R_L = 2\ k\Omega$, $V_S = \pm15V$	±10			±10			V
Output Current Swing	$V_{OUT} = \pm10V$, $T_A = 25°C$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current	$T_A = 25°C$		25			25		mA
Supply Current	$V_S = \pm15V$		5	8		7	12	mA
Power Consumption	$V_S = \pm15V$			240			360	mW

ac electrical characteristics ($T_A = 25°C$, $V_S = \pm15V$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0062			LH0062C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	Voltage Follower	50	70		50	70		V/µs
Large Signal Bandwidth	Voltage Follower		2			2		MHz
Small Signal Bandwidth			15			15		MHz
Rise Time			25			25		ns
Overshoot			10			15		%
Settling Time (0.1%)	$\Delta V_{IN} = 10V$		1			1		µs
Overload Recovery			0.9			0.9		µs
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 10\ Hz$		150			150		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 100\ Hz$		55			55		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 1\ kHz$		35			35		$nV/\sqrt{Hz}$
Input Noise Voltage	$R_S = 10\ k\Omega$, $f_o = 10\ kHz$		30			30		$nV/\sqrt{Hz}$
Input Noise Voltage	BW = 10 Hz to 10 kHz, $R_S = 10\ k\Omega$		12			12		µVrms
Input Noise Current	BW = 10 Hz to 10 kHz		<.1			<.1		pArms

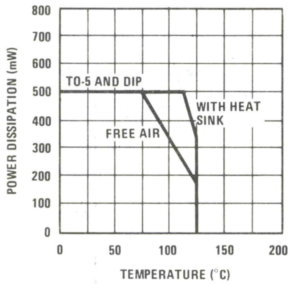
Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 2: Rating applies for minimum source resistance of 10 kΩ, for source resistances less than 10 kΩ, maximum differential input voltage is ±5V.

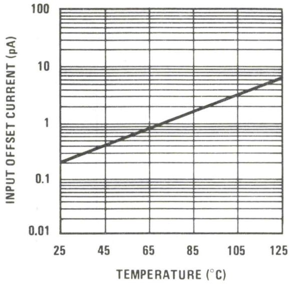
Note 3: Unless otherwise specified, these specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $-55°C \leq T_A \leq +125°C$ for the LH0062 and $-25°C \leq T_A \leq +85°C$ for LH0062C. Typical values are given for $T_A = 25°C$. Power supplies should be bypassed with 0.1 µF ceramic capacitors.

typical performance characteristics

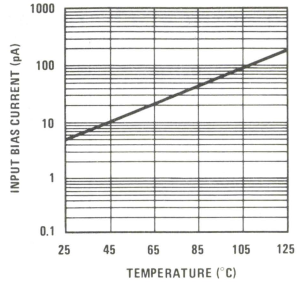
Maximum Power Dissipation



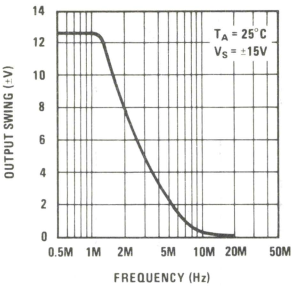
Input Offset Current vs Temperature



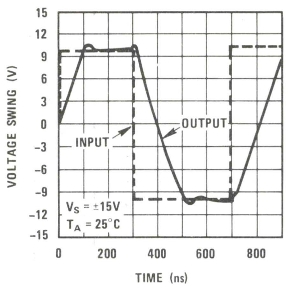
Input Bias Current vs Temperature



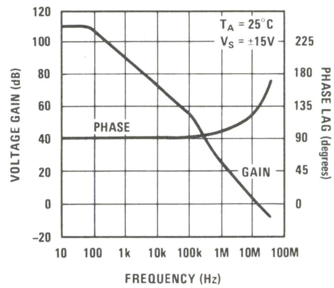
Large Signal Frequency Response



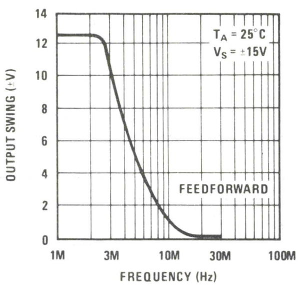
Voltage Follower Pulse Response



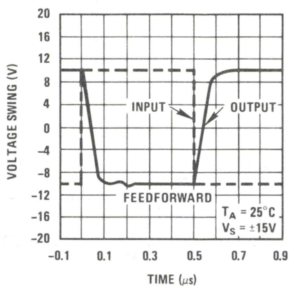
Open Loop Frequency Response



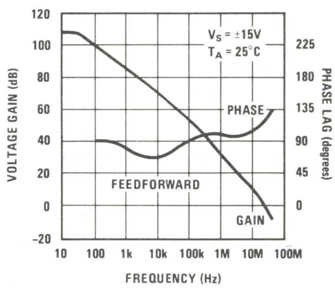
Large Signal Frequency Response



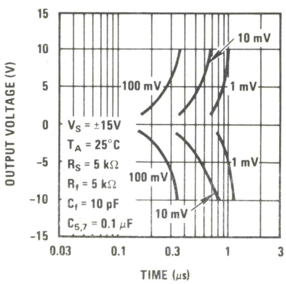
Inverter Pulse Response



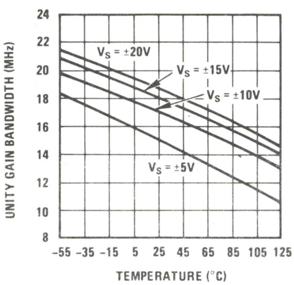
Open Loop Frequency Response



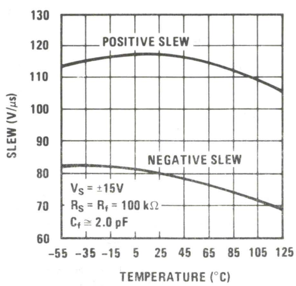
Inverter Settling Time



Unity Gain Bandwidth

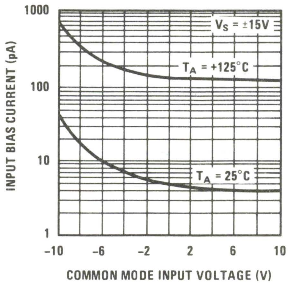


Voltage Follower Slew Rate

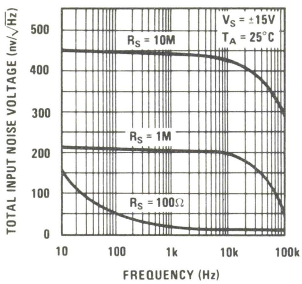


typical performance characteristics (con't)

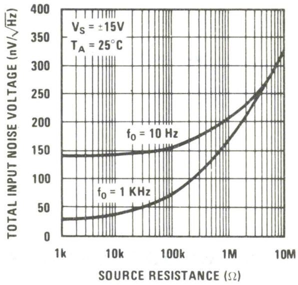
Input Bias Current vs Input Voltage



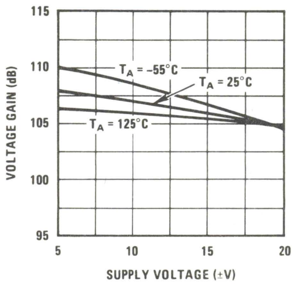
Total Input Noise Voltage* vs Frequency



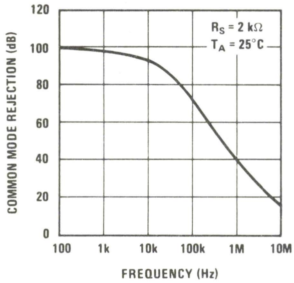
Total Input Noise Voltage* vs Source Resistance



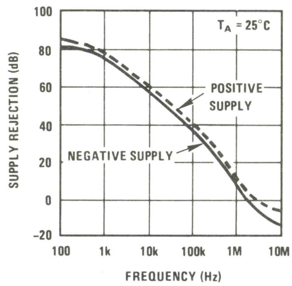
Voltage Gain



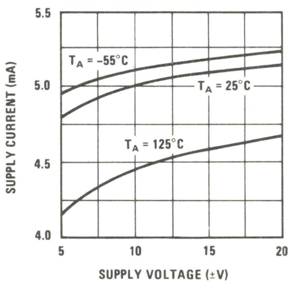
Common Mode Rejection



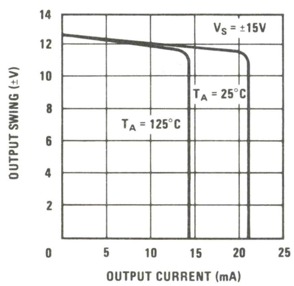
Power Supply Rejection



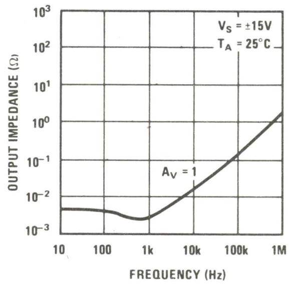
Supply Current



Current Limiting



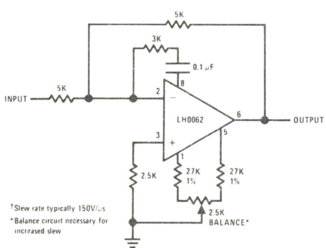
Closed Loop Output Impedance



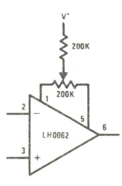
*Noise Voltage Includes Contribution from Source Resistance

auxiliary circuits

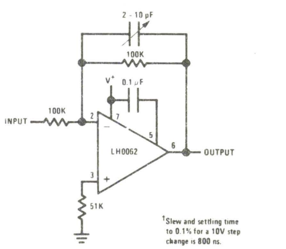
Feedforward Compensation for Greater Inverting Slew Rate†



Offset Balancing

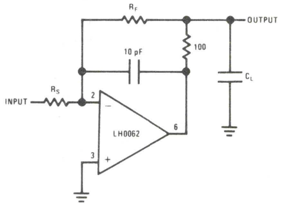


Compensation for Minimum Settling† Time

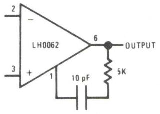


auxiliary circuits (con't)

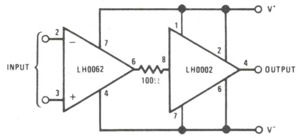
Isolating Large Capacitive Loads



Overcompensation

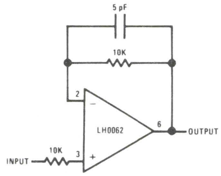


Boosting Output Drive to ±100 mA

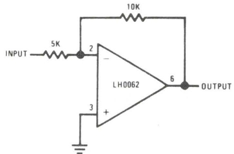


typical applications*

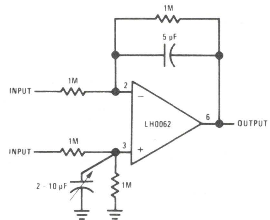
Fast Voltage Follower



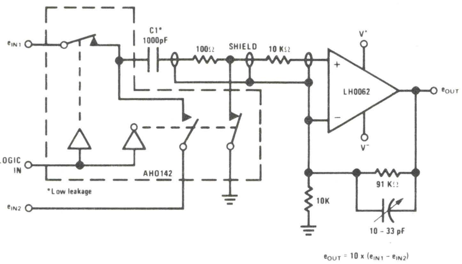
Fast Summing Amplifier



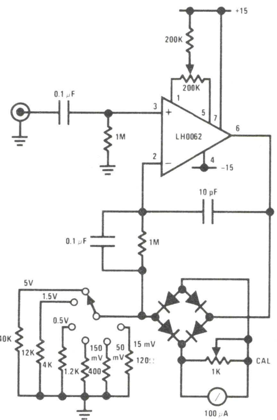
Differential Amplifier



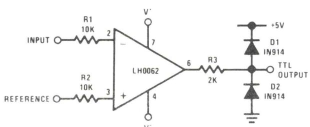
High Speed Subtractor



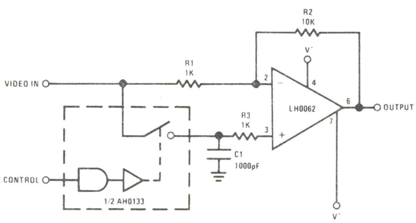
Wide Range AC Voltmeter



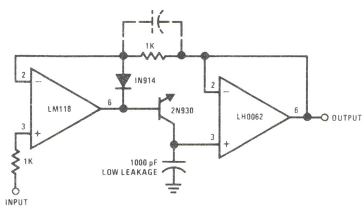
Fast Precision Voltage Comparator



Video DC Restoring Amplifier



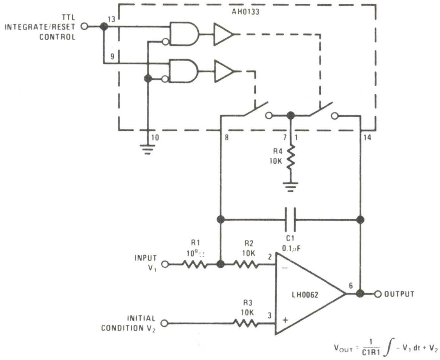
High Speed Positive Peak Detector



*Pin numbers shown for TO-5 package

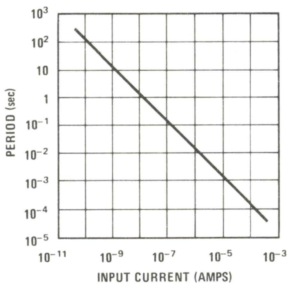
typical applications* (con't)

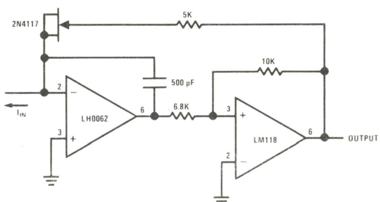
Precision Integrator



*Pin numbers shown for TO-5 package

Precision Wide Range Current to Period Converter





Operational Amplifiers

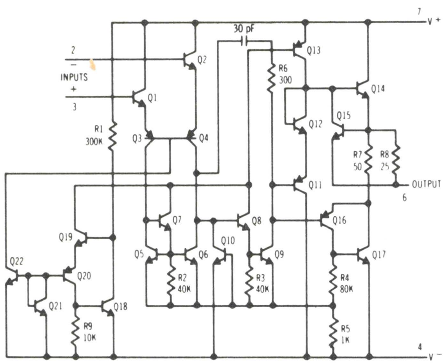
LH101 operational amplifier general description

The LH101 is a general-purpose operational amplifier which is internally compensated for unity-gain feedback. The device combines a LM101 operational amplifier and the 30 pF compensation capacitor in a single package. As such, it is a direct, plug-in replacement for both the LM101 and the LM709 in the majority of applications. Features of the amplifier include:

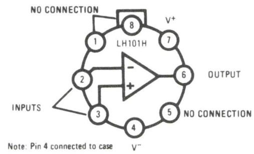
- Operation guaranteed for supply voltages from ±5V to ±20V
- Low current drain — even with the output saturated
- No latch-up when common-mode range is exceeded
- Continuous short-circuit protection
- Input transistors protected from excessive input voltage.

The LH101 is available in either an 8-lead, low-profile TO-5 header or a 1/4" x 1/4" metal flat package.

schematic** and connection diagrams

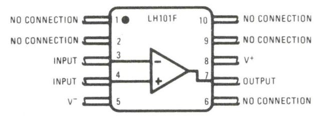


Metal Can



Order Number LH101H
See Package 11

Flat Pack

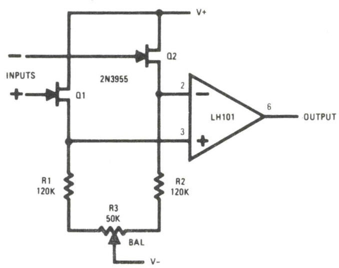


NOTE: Pin 5 connected to bottom of package.

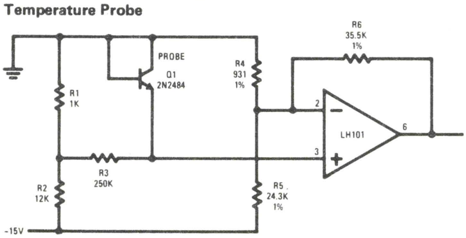
Order Number LH101F
See Package 3

typical applications **

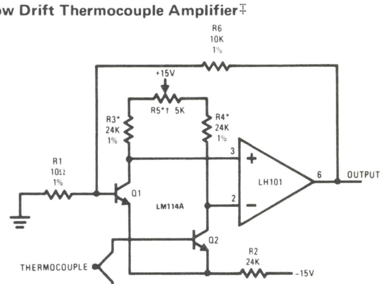
FET Operational Amplifier



Temperature Probe

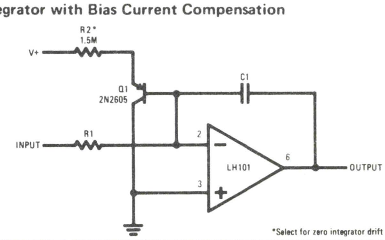


Low Drift Thermocouple Amplifier‡



* Must have matched temperature coefficients
† Adjust for zero input offset voltage
‡ Drifts less than 0.5 μV/°C can be obtained consistently

Integrator with Bias Current Compensation



*Select for zero integrator drift

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

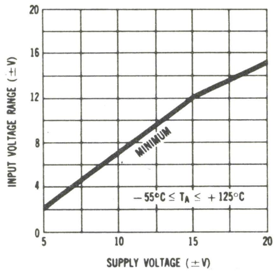
electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10k\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25°C$		40	200	nA
Input Bias Current	$T_A = 25°C$		120	500	nA
Input Resistance	$T_A = 25°C$	300	800		kΩ
Supply Current	$T_A = 25°C$, $V_S = \pm20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 2k\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 10k\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$ $R_S \leq 10k\Omega$		3.0 6.0		μV/°C μV/°C
Input Offset Current	$T_A = +125°C$ $T_A = -55°C$		10 100	200 500	nA nA
Input Bias Current	$T_A = -55°C$		0.28	1.5	μA
Supply Current	$T_A = +125°C$, $V_S = \pm20V$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 2k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10k\Omega$ $R_L = 2k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$	70	90		dB

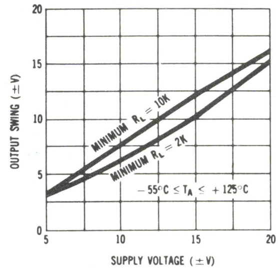
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.
Note 4: These specifications apply for $-55°C \leq T_A \leq 125°C$, $\pm5V \leq V_S \leq \pm20V$ and C1 = 30 pF unless otherwise specified.

guaranteed performance characteristics

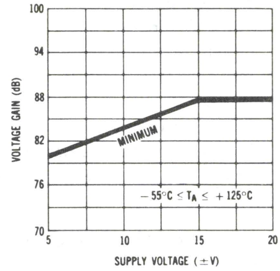
Input Voltage Range



Output Swing

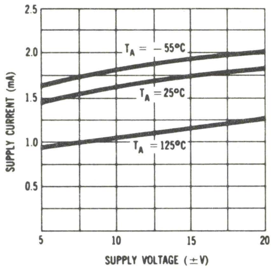


Voltage Gain

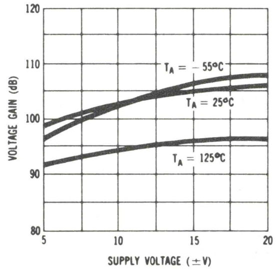


typical performance characteristics

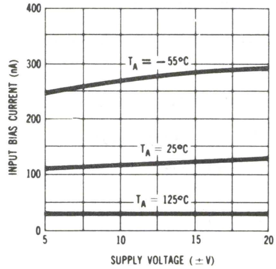
Supply Current



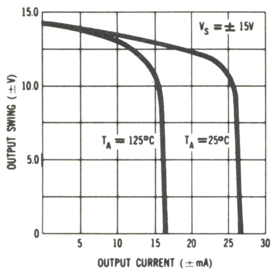
Voltage Gain



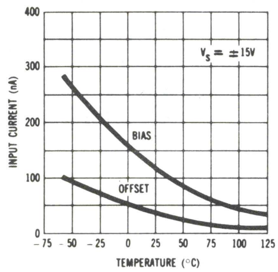
Input Bias Current



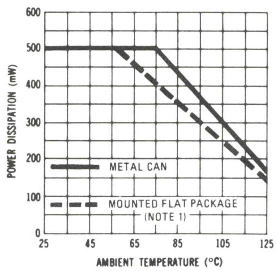
Current Limiting



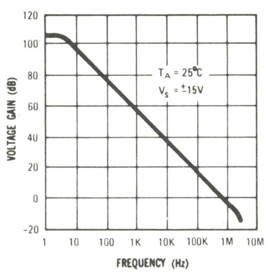
Input Current



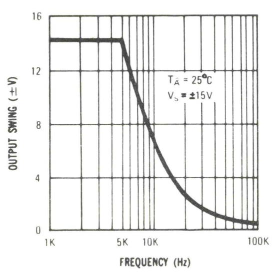
Maximum Power Dissipation



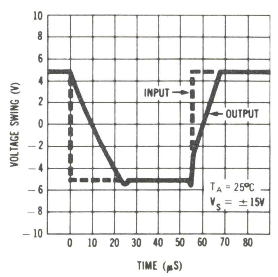
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

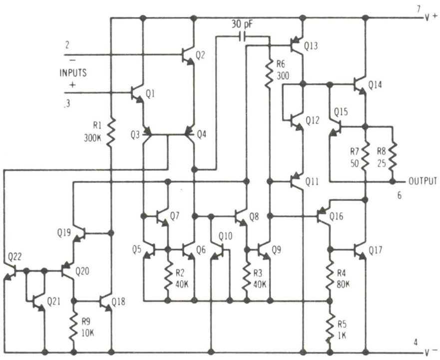
LH201 operational amplifier general description

The LH201 is a general-purpose operational amplifier which is internally compensated for unity-gain feedback. The device combines a LM201 operational amplifier and the 30 pF compensation capacitor in a single package. As such, it is a direct, plug-in replacement for both the LM201 and the LM709C in the majority of applications. It is identical to the LH101 except that operation is specified over a 0 to 70°C temperature range. Features of the amplifier include:

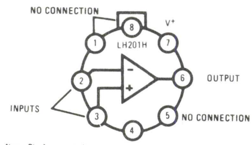
- Operation guaranteed for supply voltages from ±5V to ±20V
- Low current drain — even with the output saturated
- No latch-up when common-mode range is exceeded
- Continuous short-circuit protection
- Input transistors protected from excessive input voltage.

The LH201 is available in either an 8-lead, low-profile TO-5 header or a 1/4" x 1/4" metal flat package.

schematic** and connection diagrams



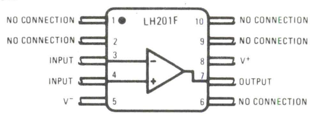
Metal Can



Note: Pin 4 connected to case V⁻

Order Number LH201H
See Package 11

Flat Pack

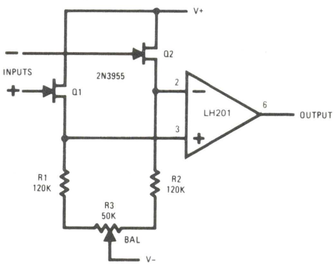


NOTE: Pin 5 connected to bottom of package.

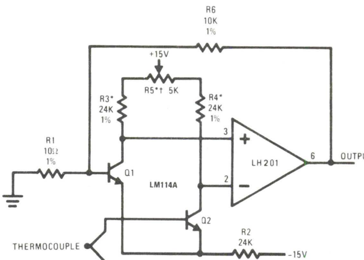
Order Number LH201F
See Package 3

typical applications**

FET Operational Amplifier

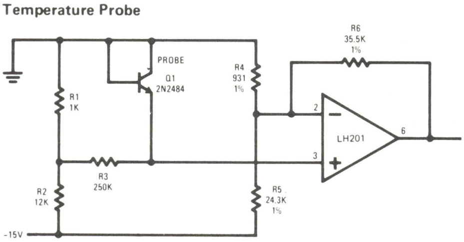


Low Drift Thermocouple Amplifier ‡

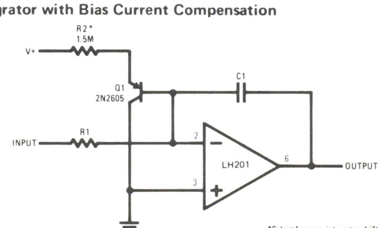


*Must have matched temperature coefficients
†Adjust for zero input offset voltage
‡Drifts less than 0.5μV/°C can be obtained consistently

Temperature Probe



Integrator with Bias Current Compensation



*Select for zero integrator drift

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

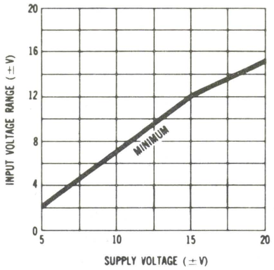
electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10k\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		100	500	nA
Input Bias Current	$T_A = 25°C$		0.25	1.5	μA
Input Resistance	$T_A = 25°C$	150	400		kΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2k\Omega$	20	150		V/mV
Input Offset Voltage	$R_S \leq 10k\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$ $R_S \leq 10k\Omega$		6 10		μV/°C μV/°C
Input Offset Current	$T_A = +70°C$ $T_A = 0°C$		50 150	400 750	nA nA
Input Bias Current	$T_A = 0°C$		0.32	2.0	μA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10k\Omega$ $R_L = 2k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	65	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$	70	90		dB

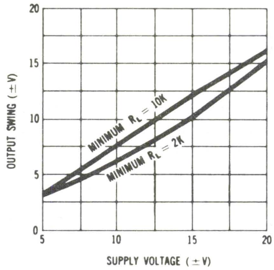
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.
Note 4: These specifications apply for $-55°C \leq T_A \leq 125°C$, $\pm 5V, \leq V_S \leq \pm 20V$ and C1 = 30 pF unless otherwise specified.

guaranteed performance characteristics

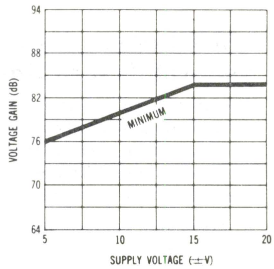
Input Voltage Range



Output Swing

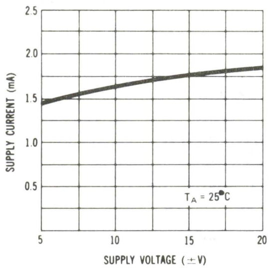


Voltage Gain

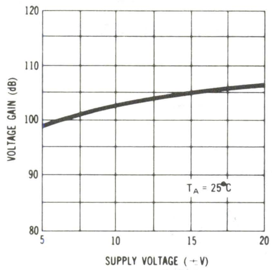


typical performance characteristics

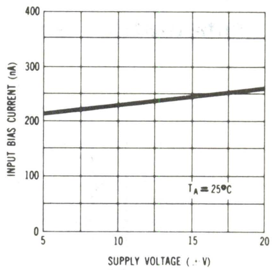
Supply Current



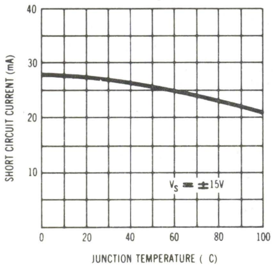
Voltage Gain



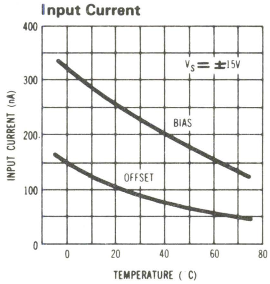
Input Bias Current



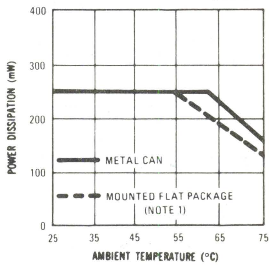
Current Limiting



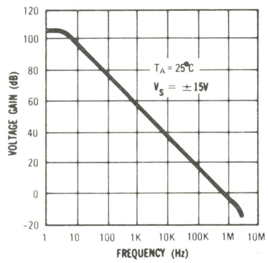
Input Current



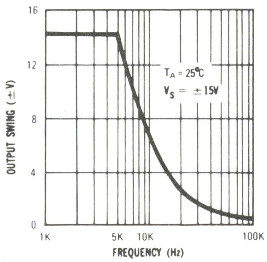
Maximum Power Dissipation



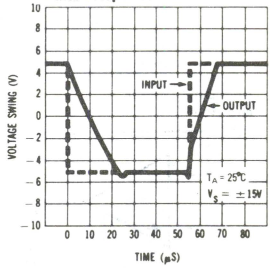
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

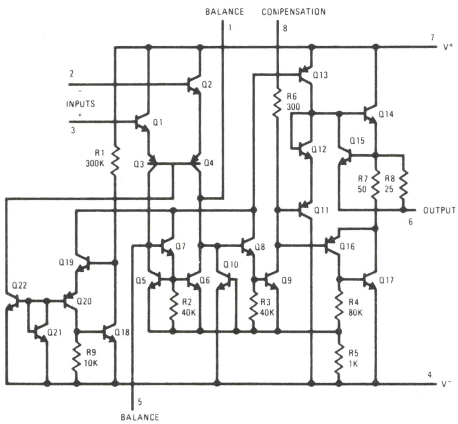
LM101 operational amplifier general description

The LM101 is a general-purpose operational amplifier built on a single silicon chip. The resulting close match and tight thermal coupling gives low offsets and temperature drift as well as fast recovery from thermal transients. In addition, the device features:

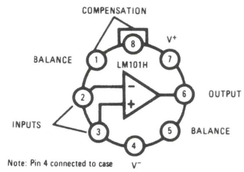
- Frequency compensation with a single 30 pF capacitor
- Operation from ±5V to ±20V
- Low current drain: 1.8 mA at ±20V
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as ±30V
- No latch-up when common mode range is exceeded
- Same pin configuration as the LM709.

The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits. Further, the low power dissipation permits high-voltage operation and simplifies packaging in full-temperature-range systems.

schematic** and connection diagrams

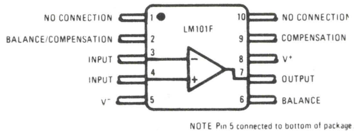


Metal Can



Order Number LM101H
See Package 11

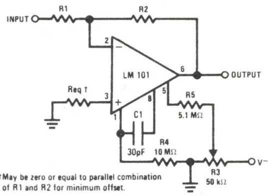
Flat Package



Order Number LM101F
See Package 3

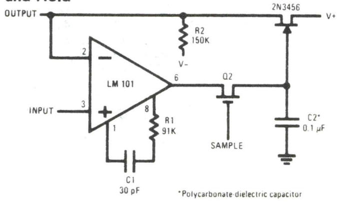
typical applications **

Inverting Amplifier with Balancing Circuit



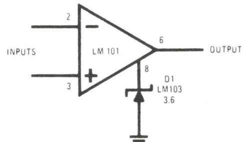
†May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Low Drift Sample and Hold

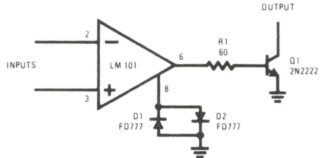


*Polycarbonate dielectric capacitor

Voltage Comparator for Driving DTL or TTL Integrated Circuits



Voltage Comparator for Driving RTL Logic or High Current Driver



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

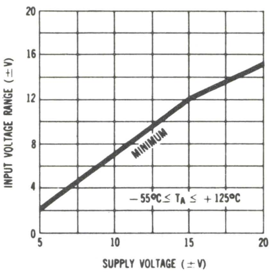
electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10k\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25°C$		40	200	nA
Input Bias Current	$T_A = 25°C$		120	500	nA
Input Resistance	$T_A = 25°C$	300	800		kΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2k\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 10k\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$ $R_S \leq 10k\Omega$		3.0 6.0		μV/°C μV/°C
Input Offset Current	$T_A = +125°C$ $T_A = -55°C$		10 100	200 500	nA nA
Input Bias Current	$T_A = -55°C$		0.28	1.5	μA
Supply Current	$T_A = +125°C$, $V_S = \pm 20V$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10k\Omega$ $R_L = 2k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$	70	90		dB

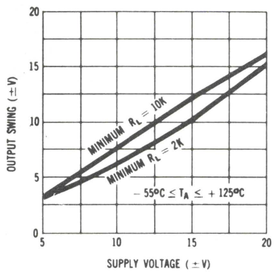
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.
Note 4: These specifications apply for $-55°C \leq T_A \leq 125°C$, $\pm 5V \leq V_S \leq \pm 20V$ and C1 = 30 pF unless otherwise specified.

guaranteed performance characteristics

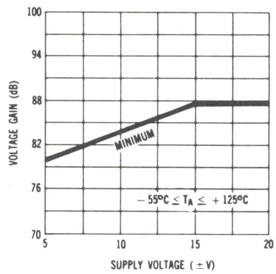
Input Voltage Range



Output Swing

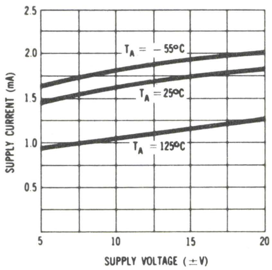


Voltage Gain

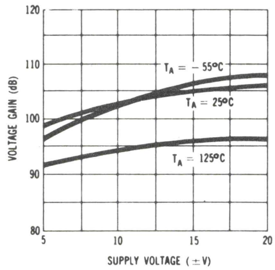


typical performance characteristics

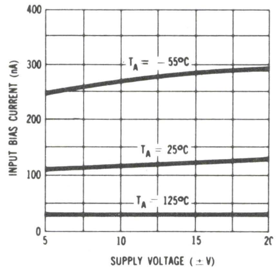
Supply Current



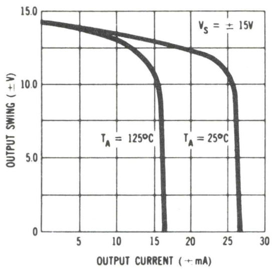
Voltage Gain



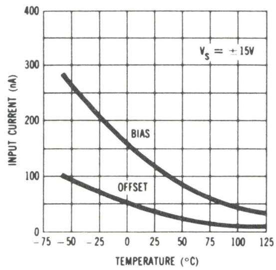
Input Bias Current



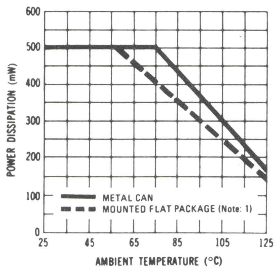
Current Limiting



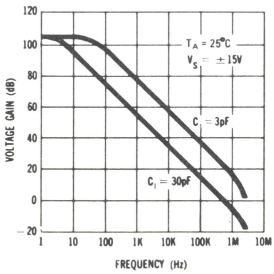
Input Current



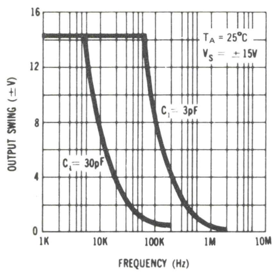
Maximum Power Dissipation



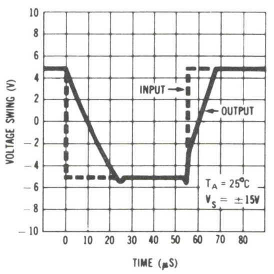
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

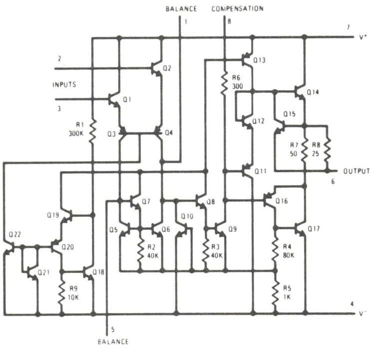
LM201 operational amplifier general description

The LM201 is a general-purpose operational amplifier built on a single silicon chip. It is identical to the LM101 except that operation is specified over a 0 to 70°C temperature range. The device features:

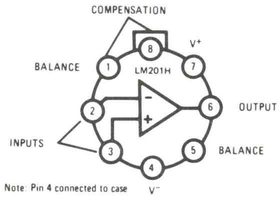
- Frequency compensation with a single 30 pF capacitor
- Operation from ±5V to ±20V
- Low current drain: 1.8 mA at ±20V
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as ±30V
- No latch-up when common mode range is exceeded
- LM709 lead configuration in metal cans and flat-packages.

The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits. Further, the low power dissipation permits high-voltage operation and simplifies packaging.

schematic** and connection diagrams



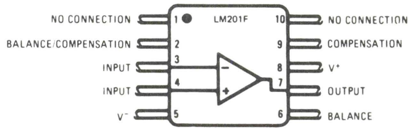
Metal Can



Note: Pin 4 connected to case

Order Number LM201H
See Package 11

Flat Pack

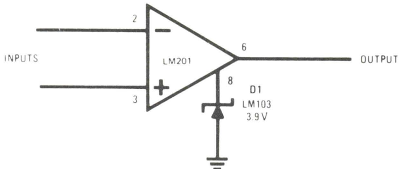


NOTE: Pin 5 connected to bottom of package

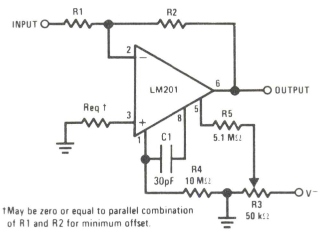
Order Number LM201F
See Package 3

typical applications**

Voltage Comparator for Driving DTL or TTL Integrated Circuits

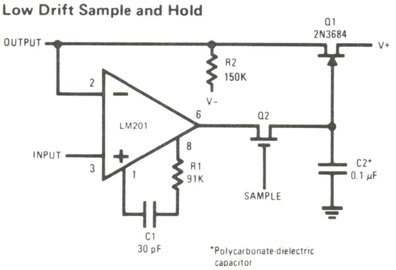


Inverting Amplifier with Balancing Circuit



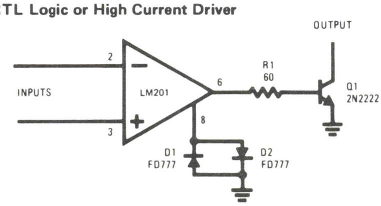
†May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Low Drift Sample and Hold



*Polycarbonate-dielectric capacitor

Voltage Comparator for Driving RTL Logic or High Current Driver



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

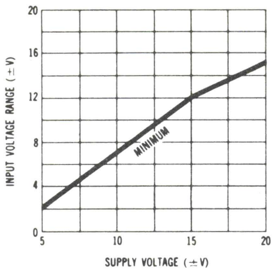
electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \le 10k\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		100	500	nA
Input Bias Current	$T_A = 25°C$		0.25	1.5	μA
Input Resistance	$T_A = 25°C$	100	400		kΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \ge 2k\Omega$	20	150		V/mV
Input Offset Voltage	$R_S \le 10k\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \le 50\Omega$ $R_S \le 10k\Omega$		6 10		μV/°C μV/°C
Input Offset Current	$T_A = +70°C$ $T_A = 0°C$		50 150	400 750	nA nA
Input Bias Current	$T_A = 0°C$		0.32	2.0	μA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \ge 2k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10k\Omega$ $R_L = 2k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			V
Common Mode Rejection Ratio	$R_S \le 10k\Omega$	65	90		dB
Supply Voltage Rejection Ratio	$R_S \le 10k\Omega$	70	90		dB

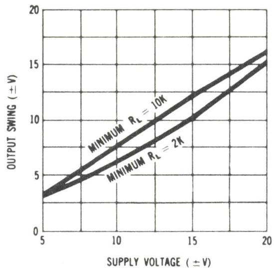
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.
Note 4: These specifications apply for $0°C \le T_A \le 70°C$, $\pm 5V, \le V_S \le \pm 20V$ and C1 = 30 pF unless otherwise specified.

guaranteed performance characteristics

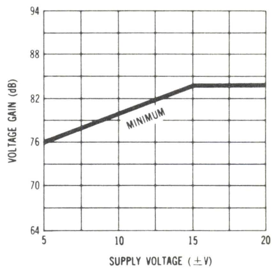
Input Voltage Range



Output Swing

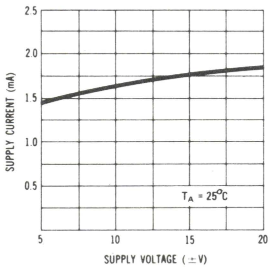


Voltage Gain

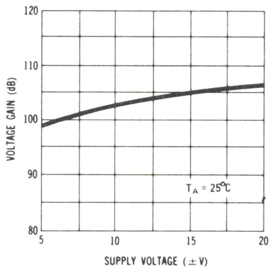


typical performance characteristics

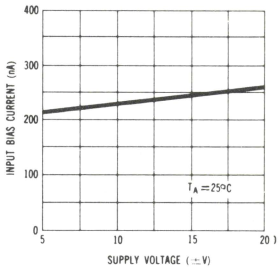
Supply Current



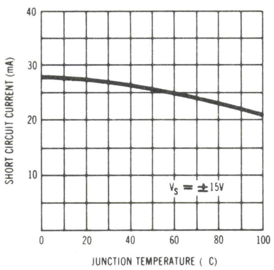
Voltage Gain



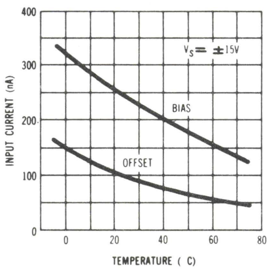
Input Bias Current



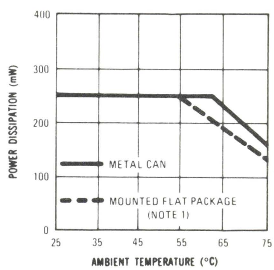
Short Circuit Current



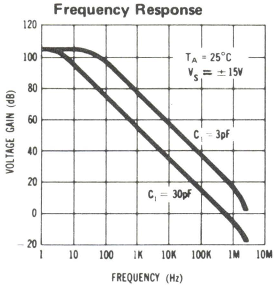
Input Current



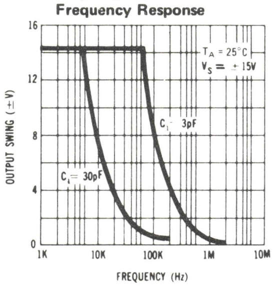
Maximum Power Dissipation



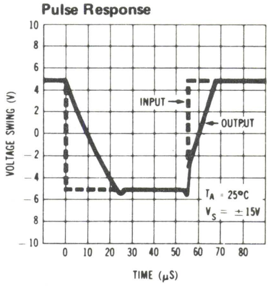
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM101A/LM201A operational amplifier

general description

The LM101A and LM201A are general purpose operational amplifiers which feature improved performance over industry standards like the LM101 and the 709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current. Improved specifications include:

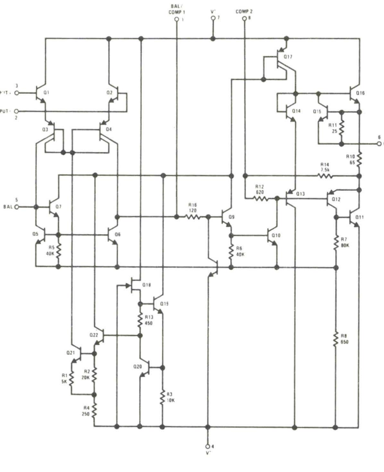
- Offset voltage 3 mV maximum over temperature
- Input current 100 nA maximum over temperature
- Offset current 20 nA maximum over temperature
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF capacitor. It has advantages over internally compensated amplifiers in that the frequency compensation can be tailored to the particular application. For example, in low frequency circuits it can be overcompensated for increased stability margin. Or the compensation can be optimized to give more than a factor of ten improvement in high frequency performance for most applications.

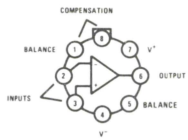
The LM101A series offers the features of the LM101, which makes its application nearly foolproof. In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

The LM201A is identical to the LM101A, except that the LM201A has its performance guaranteed over a –25°C to 85°C temperature range, instead of –55°C to 125°C.

schematic** and connection diagrams



Metal Can

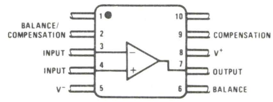


Note: Pin 4 connected to case

TOP VIEW

Order Number LM101AH or LM201AH
See Package 11

Flat Package

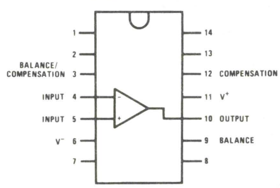


Note: Pin 5 connected to bottom of package

TOP VIEW

Order Number LM101AF or LM201AF
See Package 3

Dual-In-Line



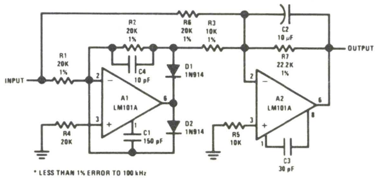
Note: Pin 6 connected to bottom of package

TOP VIEW

Order Number LM101AD or LM201AD
See Package 1

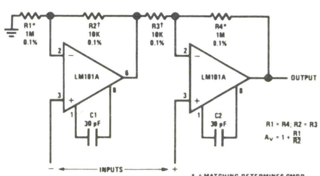
typical applications**

Fast AC/DC Converter*



* LESS THAN 1% ERROR TO 100 kHz

Instrumentation Amplifier



*, † MATCHING DETERMINES CMRR

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration (Note 3)		Indefinite
Operating Temperature Range	LM101A	−55°C to 125°C
	LM201A	−25°C to 85°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$		0.7	2.0	mV
Input Offset Current	$T_A = 25°C$		1.5	10	nA
Input Bias Current	$T_A = 25°C$		30	75	nA
Input Resistance	$T_A = 25°C$	1.5	4		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	μV/°C
Input Offset Current				20	nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 125°C$ $-55°C \leq T_A \leq 25°C$		0.01 0.02	0.1 0.2	nA/°C nA/°C
Input Bias Current				100	nA
Supply Current	$T_A = +125°C$, $V_S = \pm 20V$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 20V$	±15			V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	80	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	80	96		dB

Note 1: The maximum junction temperature of the LM101A is 150°C, while that of the LM201A is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

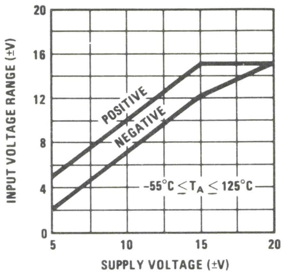
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +75°C.

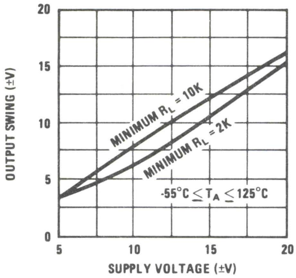
Note 4: These specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM201A, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$.

guaranteed performance characteristics

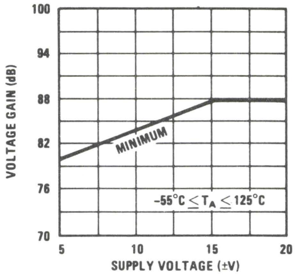
Input Voltage Range



Output Swing

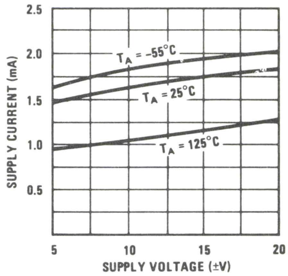


Voltage Gain

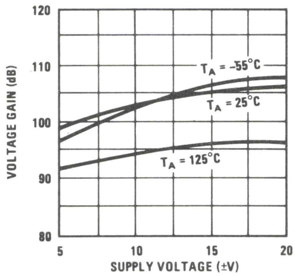


typical performance characteristics

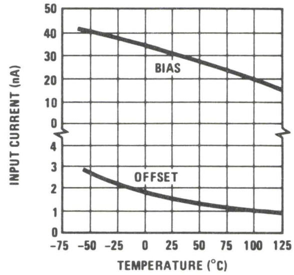
Supply Current



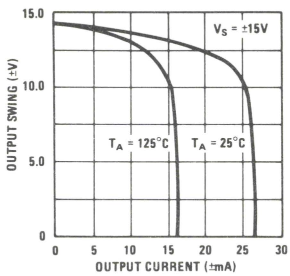
Voltage Gain



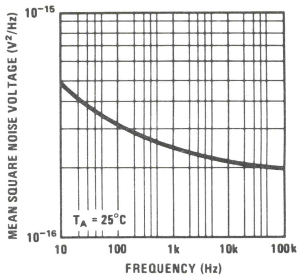
Input Current



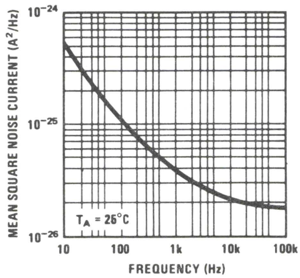
Current Limiting



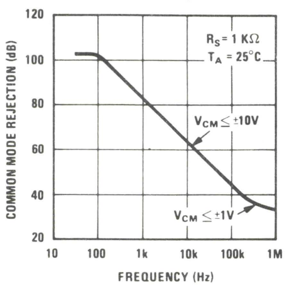
Input Noise Voltage



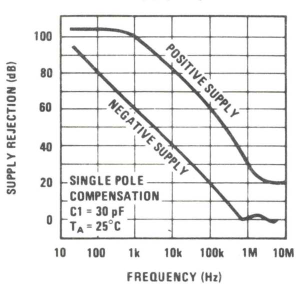
Input Noise Current



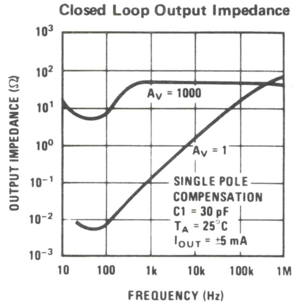
Common Mode Rejection



Power Supply Rejection

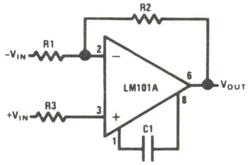


Closed Loop Output Impedance



compensation circuits**

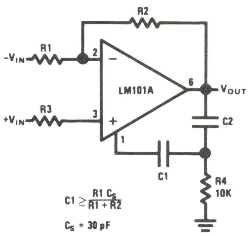
Single Pole Compensation



$C1 \geq \frac{R1\ C_S}{R1 + R2}$

$C_S = 30\ pF$

Two Pole Compensation

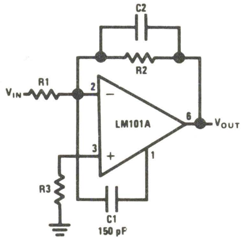


$C1 \geq \frac{R1\ C_S}{R1 + R2}$

$C_S = 30\ pF$

$C2 = 10\ C1$

Feedforward Compensation



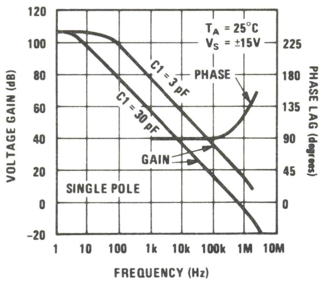
$C2 = \frac{1}{2\pi f_o R2}$

$f_o = 3\ MHz$

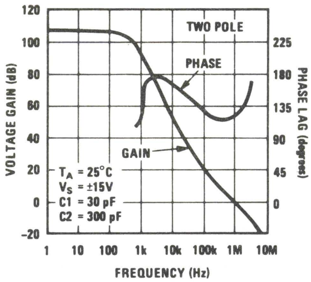
**Pin connections shown are for metal can.

typical performance characteristics (con't)

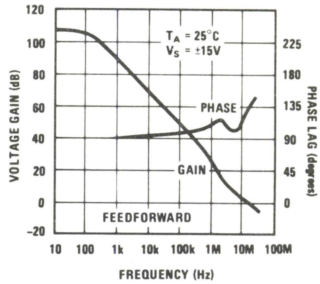
Open Loop Frequency Response



Open Loop Frequency Response

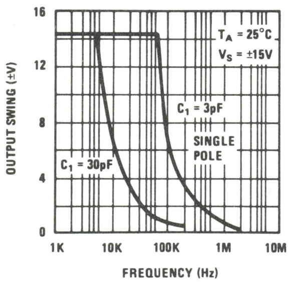


Open Loop Frequency Response

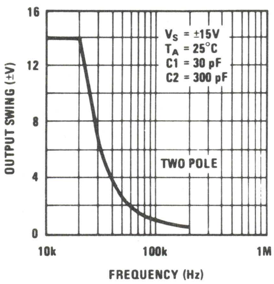


2

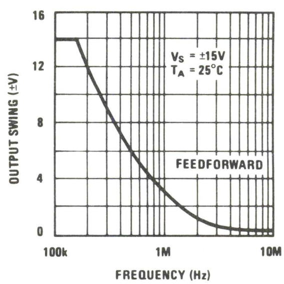
Large Signal Frequency Response



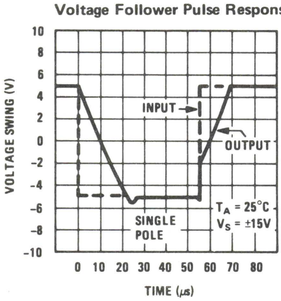
Large Signal Frequency Response



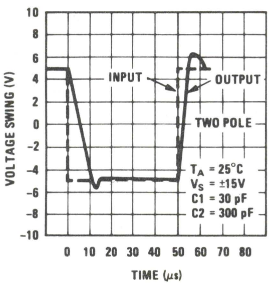
Large Signal Frequency Response



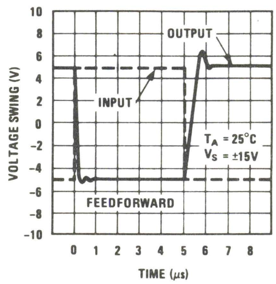
Voltage Follower Pulse Response



Voltage Follower Pulse Response

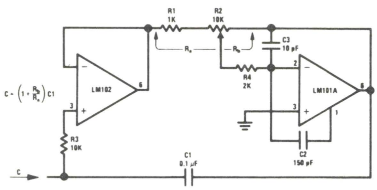


Inverter Pulse Response

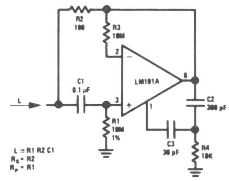


typical applications ** (con't)

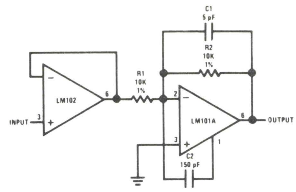
Variable Capacitance Multiplier



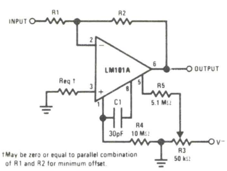
Simulated Inductor



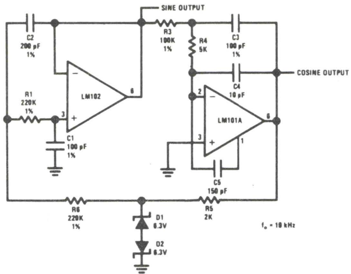
Fast Inverting Amplifier With High Input Impedance



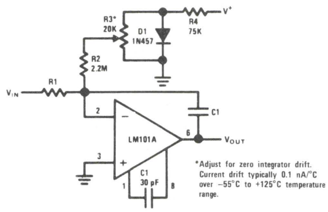
Inverting Amplifier with Balancing Circuit



Sine Wave Oscillator

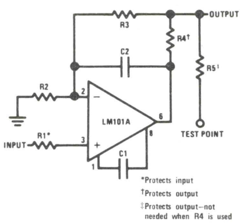


Integrator with Bias Current Compensation

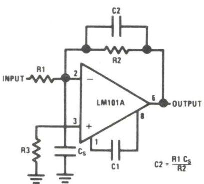


application hints**

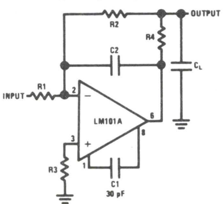
Protecting Against Gross Fault Conditions



Compensating For Stray Input Capacitances Or Large Feedback Resistor



Isolating Large Capacitive Loads



Although the LM101A is designed for trouble free operation, experience has indicated that it is wise to observe certain precautions given below to protect the devices from abnormal operating conditions. It might be pointed out that the advice given here is applicable to practically any IC op amp, although the exact reason why may differ with different devices.

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak instantaneous output current of the source to something less than 100 mA. This is especially important when the inputs go outside a piece of equipment where they could accidentally be connected to high voltage sources. Large capacitors on the input (greater than 0.1 μF) should be treated as a low source impedance and isolated with a resistor. Low impedance sources do not cause a problem unless their output voltage exceeds the supply voltage. However, the supplies go to zero when they are turned off, so the isolation is usually needed.

The output circuitry is protected against damage from shorts to ground. However, when the amplifier output is connected to a test point, it should be isolated by a limiting resistor, as test points frequently get shorted to bad places. Further, when the amplifier drives a load external to the equipment, it is also advisable to use some sort of limiting resistance to preclude mishaps.

Precautions should be taken to insure that the power supplies for the integrated circuit never become reversed—even under transient conditions. With reverse voltages greater than 1V, the IC will conduct excessive current, fuzing internal aluminum interconnects. If there is a possibility of this happening, clamp diodes with a high peak current rating should be installed on the supply lines. Reversal of the voltage between V^+ and V^- will always cause a problem, although reversals with respect to ground may also give difficulties in many circuits.

The minimum values given for the frequency compensation capacitor are stable only for source resistances less than 10 kΩ, stray capacitances on the summing junction less than 5 pF and capacitive loads smaller than 100 pF. If any of these conditions are not met, it becomes necessary to overcompensate the amplifier with a larger compensation capacitor. Alternately, lead capacitors can be used in the feedback network to negate the effect of stray capacitance and large feedback resistors or an RC network can be added to isolate capacitive loads.

Although the LM101A is relatively unaffected by supply bypassing, this cannot be ignored altogether. Generally it is necessary to bypass the supplies to ground at least once on every circuit card, and more bypass points may be required if more than five amplifiers are used. When feed-forward compensation is employed, however, it is advisable to bypass the supply leads of each amplifier with low inductance capacitors because of the higher frequencies involved.

**Pin connections shown are for metal can.

Operational Amplifiers

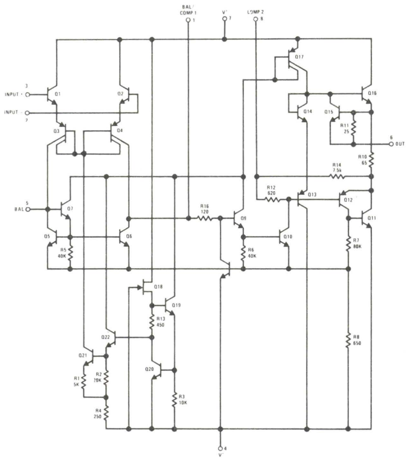
LM301A operational amplifier general description

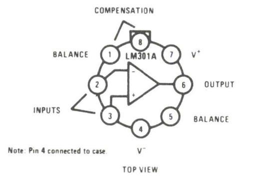
The LM301A is a general-purpose operational amplifier which features improved performance over the 709C and other popular amplifiers. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current.

This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF capacitor. It has advantages over internally compensated amplifiers in that the compensation can be tailored to the particular application. For example, as a summing amplifier, slew rates of 10 V/μs and bandwidths of 10 MHz can be realized. In addition, the circuit can be used as a comparator with differential inputs up to ±30V; and the output can be clamped at any desired level to make it compatible with logic circuits.

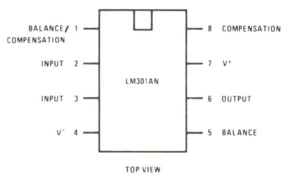
The LM301A provides better accuracy and lower noise than its predecessors in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at reduced cost.

schematic** and connection diagrams





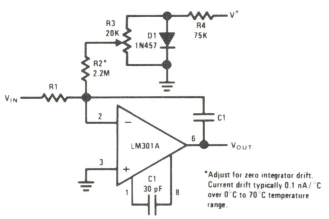
Order Number LM301AH
See Package 11



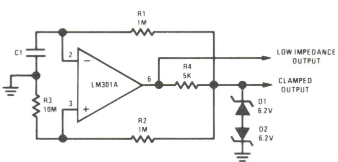
Order Number LM301AN
See Package 20

typical applications **

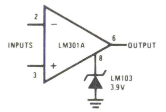
Integrator with Bias Current Compensation



Low Frequency Square Wave Generator



Voltage Comparator for Driving DTL or TTL Integrated Circuits



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		3	50	nA
Input Bias Current	$T_A = 25°C$		70	250	nA
Input Resistance	$T_A = 25°C$	0.5	2		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	25	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	μV/°C
Input Offset Current				70	nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 70°C$ $0°C \leq T_A \leq 25°C$		0.01 0.02	0.3 0.6	nA/°C nA/°C
Input Bias Current				300	nA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	70	96		dB

Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.

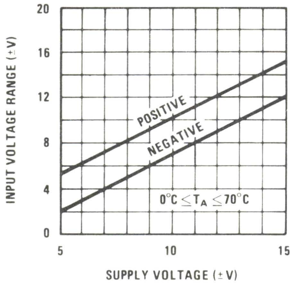
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

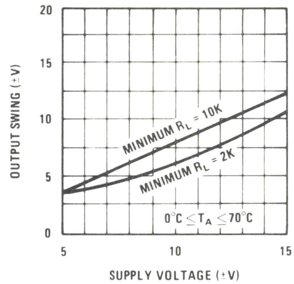
Note 4: These specifications apply for $0°C \leq T_A < 70°C$, $\pm 5V \leq V_S \leq \pm 15V$ and C1 = 30 pF unless otherwise specified.

guaranteed performance characteristics

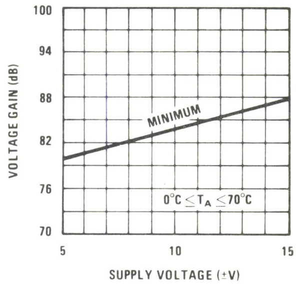
Input Voltage Range



Output Swing

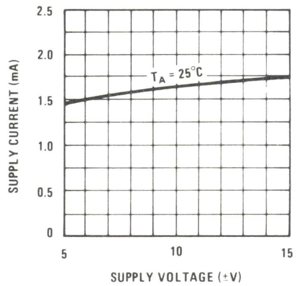


Voltage Gain

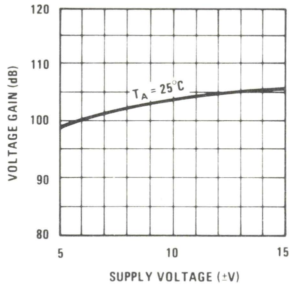


typical performance characteristics

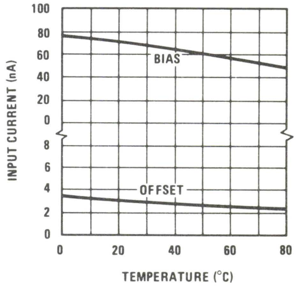
Supply Current



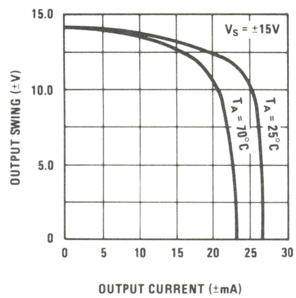
Voltage Gain



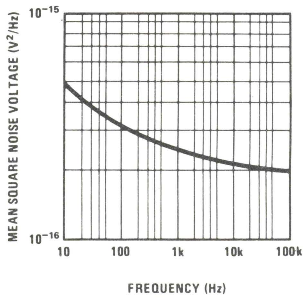
Input Current



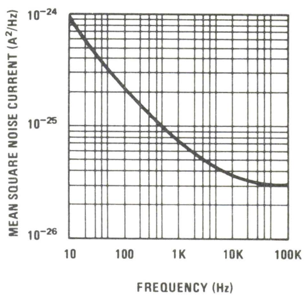
Current Limiting



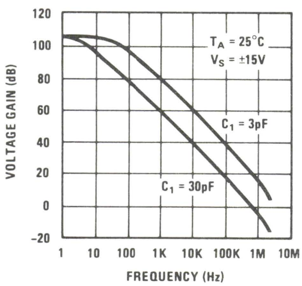
Input Noise Voltage



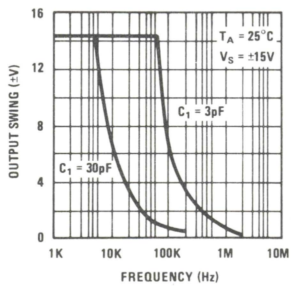
Input Noise Current



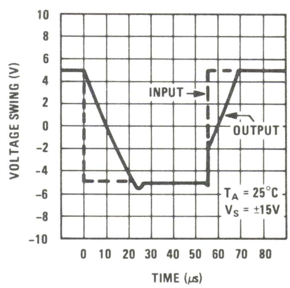
Open Loop
Frequency Response



Large Signal
Frequency Response

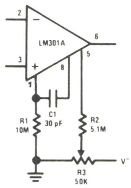


Voltage Follower
Pulse Response

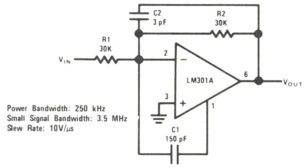


typical applications ** (con't)

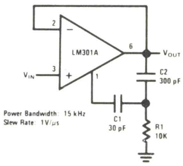
Standard Compensation and Offset Balancing Circuit



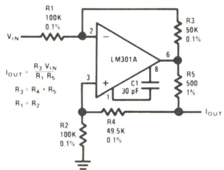
Fast Summing Amplifier



Fast Voltage Follower



Bilateral Current Source



**Pin connections shown are for metal can.

Operational Amplifiers

LM102 voltage follower

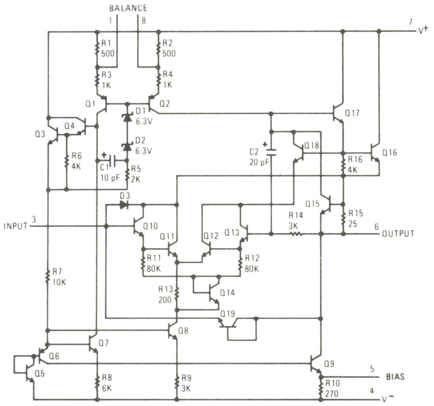
general description

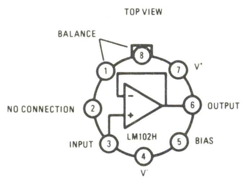
The LM102 is a high-gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast slewing — 10V/μs
- Low input current — 10 nA (max)
- High input resistance — 10,000 MΩ
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Plug-in replacement for both the LM101 and LM709 in voltage follower applications.

The LM102, which is designed to operate with supply voltages between ±12V and ±15V, also features low input capacitance as well as excellent small signal and large signal frequency response — all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic** and connection diagrams



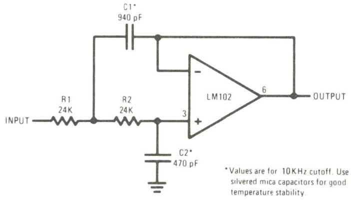


NOTE: Pin 4 connected to case.

Order Number LM102H
See Package 11

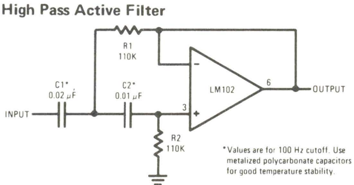
typical applications **

Low Pass Active Filter



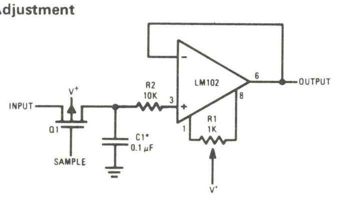
*Values are for 10KHz cutoff. Use silvered mica capacitors for good temperature stability.

High Pass Active Filter



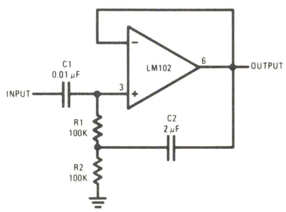
*Values are for 100 Hz cutoff. Use metalized polycarbonate capacitors for good temperature stability.

Sample and Hold With Offset Adjustment



*Polycarbonate-dielectric capacitor.

High Input Impedance AC Amplifier



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	$-55^\circ C$ to $125^\circ C$
Storage Temperature Range	$-65^\circ C$ to $150^\circ C$
Lead Temperature (soldering, 10 sec)	$300^\circ C$

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Offset Voltage			2	5	mV
Average Temperature Coefficient of Offset Voltage			6		$\mu V/^\circ C$
Input Current			3	10	nA
Input Resistance		10^{10}	10^{12}		Ω
Voltage Gain	$R_L \geq 10\ k\Omega$	0.999	0.9996		
Output Resistance			0.8	2.5	Ω
Output Voltage Swing (Note 5)	$R_L \geq 8\ k\Omega$	±10	±13		V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			dB
Negative Supply Rejection		70			dB
Input Capacitance				3.0	pF
Offset Voltage	$-55^\circ C \leq T_A \leq 125^\circ C$			7.5	mV
Input Current	$T_A = 125^\circ C$ $T_A = -55^\circ C$		3 30	10 100	nA nA
Voltage Gain	$-55^\circ C \leq T_A \leq 125^\circ C$ $R_L \geq 10\ k\Omega$	0.999			
Output Voltage Swing (Note 5)	$R_L \geq 10\ k\Omega$	±10			V
Supply Current	$T_A = 125^\circ C$		2.6	4.0	mA

Note 1: For operating at elevated temperatures, the device must be derated based on a $150^\circ C$ maximum junction temperature and a thermal resistance of $45^\circ C/W$ junction to case or $150^\circ C/W$ junction to ambient (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

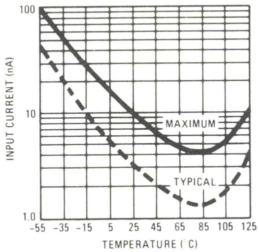
Note 3: Continuous short circuit is allowed for case temperatures to $125^\circ C$ and ambient temperatures to $70^\circ C$. It is necessary to insert a resistor greater than $2\ k\Omega$ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $T_A = 25^\circ C$, $V_S = \pm 15V$ and $C_L \leq 100$ pF unless otherwise noted

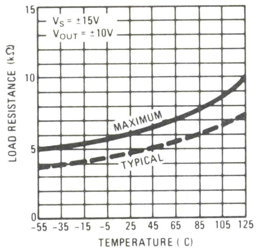
Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V^- terminals.See curve.

guaranteed performance characteristics

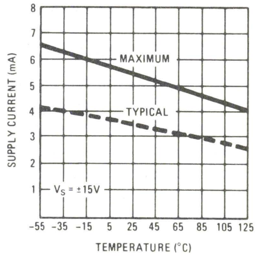
Input Current



Output Swing

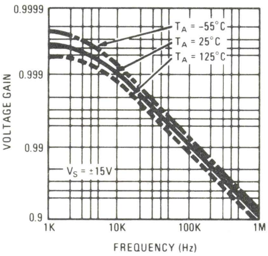


Supply Current

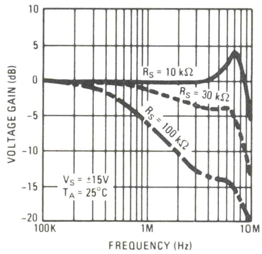


typical performance characteristics

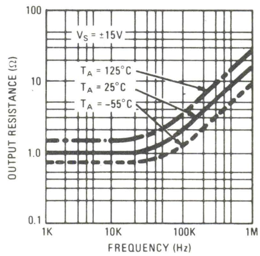
Voltage Gain



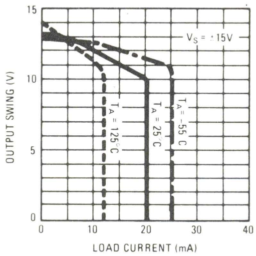
Voltage Gain



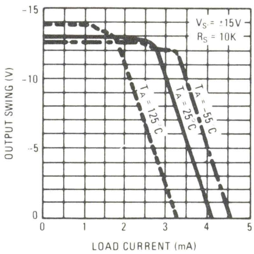
Output Resistance



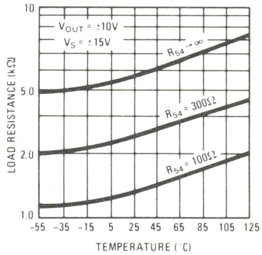
Positive Output Swing



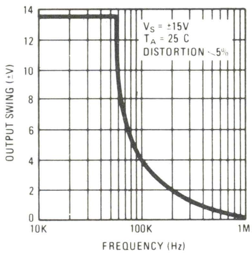
Negative Output Swing



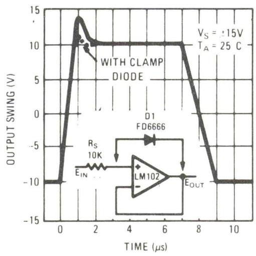
Output Swing



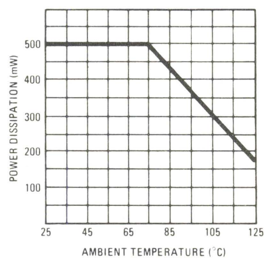
Large Signal Frequency Response



Large Signal Pulse Response



Maximum Power Dissipation



2

Operational Amplifiers

LM202 voltage follower

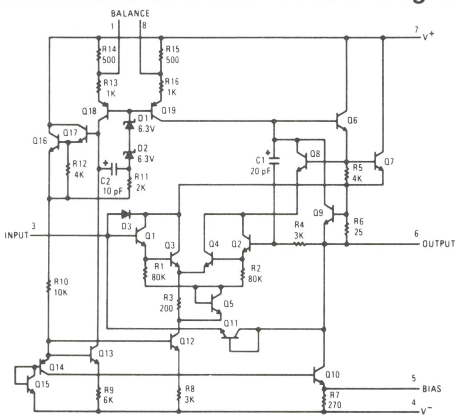
general description

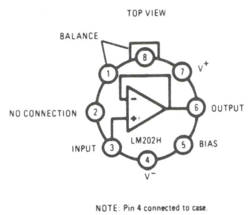
The LM202, a limited temperature range version of the LM102, is a high-gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast slewing: 10V/μs
- Low input current: 15 nA (max)
- High input resistance: 10,000 MΩ
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Specified for operation from -25°C to 85°C
- Plug-in replacement for both the LM201 and LM709C voltage follower applications.

The LM202, which is designed to operate with supply voltages between ±12V and ±15V, also features low input capacitance as well as excellent small signal and large signal frequency response — all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic and connection diagrams



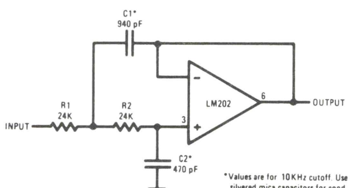


NOTE: Pin 4 connected to case.

Order Number LM202H
See Package 11

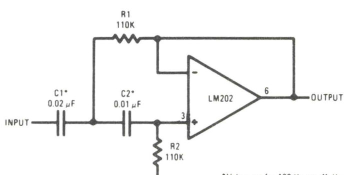
typical applications

Low Pass Active Filter



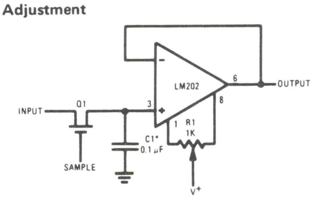
*Values are for 10KHz cutoff. Use silvered mica capacitors for good temperature stability.

High Pass Active Filter



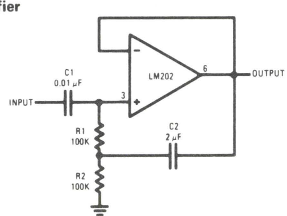
*Values are for 100 Hz cutoff. Use metalized polycarbonate capacitors for good temperature stability.

Sample and Hold With Offset Adjustment



*Polycarbonate-dielectric capacitor.

High Input Impedance AC Amplifier



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	−25°C to 85°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

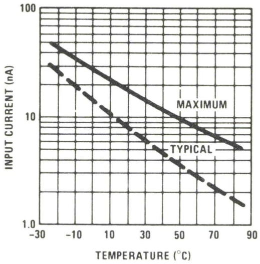
electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Offset Voltage			3	10	mV
Average Temperature Coefficient of Offset Voltage			15		μV/°C
Input Current			7	15	nA
Input Resistance		10^{10}	10^{12}		Ω
Voltage Gain	$R_L \geq 8$ KΩ	.999	0.9995	1.000	
Output Resistance			0.8	2.5	Ω
Output Voltage Swing	$R_L \geq 8$ KΩ	±10			V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			
Negative Supply Rejection		70			
Input Capacitance			3.0		pF
Offset Voltage	$-25°C \leq T_A \leq 85°C$			15	mV
Input Current	$T_A = 85°C$		1.5	5.0	nA
	$T_A = -25°C$		30	50	nA

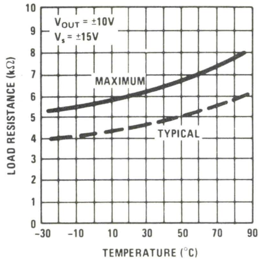
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to 85°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.
Note 4: These specifications apply for $T_A = 25°C$, $V_S = \pm 15V$ and $C_L \leq 100$ pF unless otherwise noted.

guaranteed performance characteristics

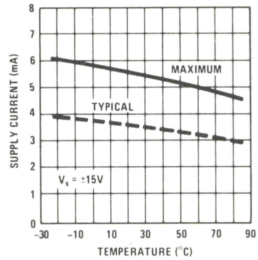
Input Current



Output Swing

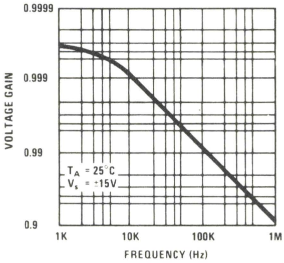


Supply Current

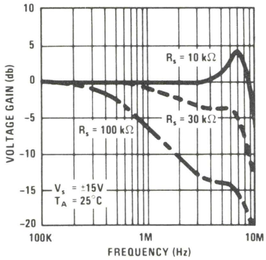


typical performance characteristics

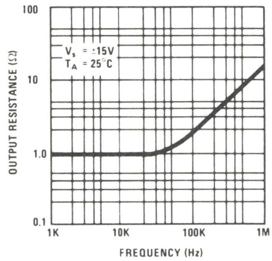
Voltage Gain



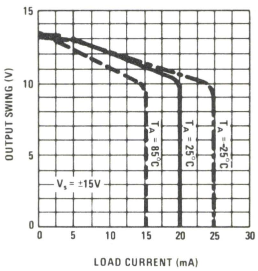
Voltage Gain



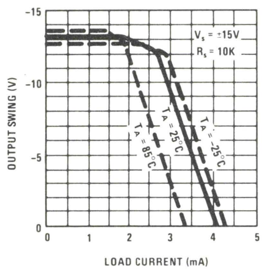
Output Resistance



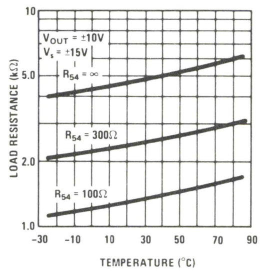
Positive Output Swing



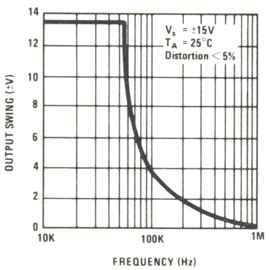
Negative Output Swing



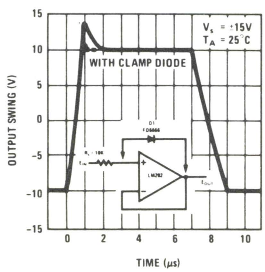
Output Swing



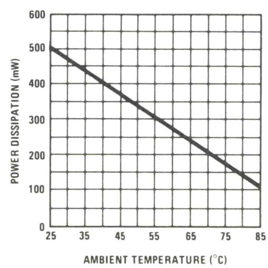
Large Signal Frequency Response



Large Signal Pulse Response



Maximum Power Dissipation



Operational Amplifiers

LM302 voltage follower

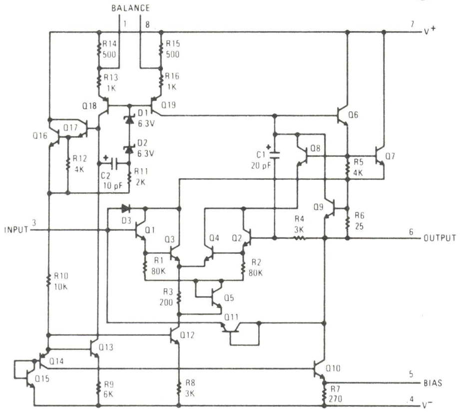
general description

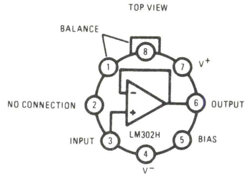
The LM302, an epoxy encapsulated version of the LM102, is a high gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast Slewing — 10V/μs
- Low input current — 30 nA (max)
- High input resistance — 1,000 MΩ
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Specified for operation from 0°C to 70°C
- Plug-in replacement for both the LM201 and LM709C in voltage follower applications.

The LM302, which is designed to operate with supply voltages between ±12V and ±15V, also features low input capacitance as well as excellent small signal and large signal frequency response — all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic and connection diagrams



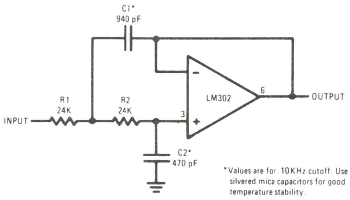


NOTE: Pin 4 connected to case.

Order Number LM302H
See Package 11

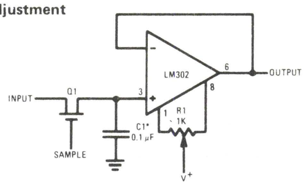
typical applications

Low Pass Active Filter



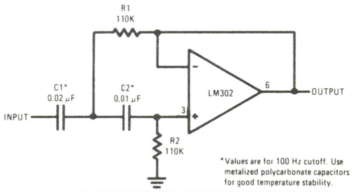
*Values are for 10KHz cutoff. Use silvered mica capacitors for good temperature stability.

Sample and Hold With Offset Adjustment



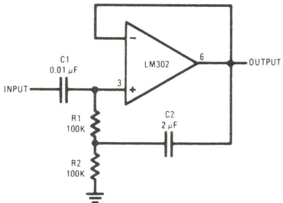
*Polycarbonate-dielectric capacitor.

High Pass Active Filter



*Values are for 100 Hz cutoff. Use metalized polycarbonate capacitors for good temperature stability.

High Input Impedance AC Amplifier



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	400 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

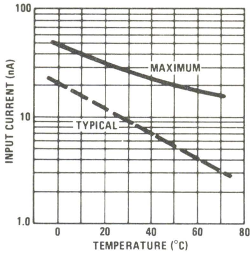
electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Offset Voltage			5	15	mV
Average Temperature Coefficient of Offset Voltage			20		μV/°C
Input Current			10	30	nA
Input Resistance		10^9	10^{12}		Ω
Voltage Gain	$R_L > 8$ KΩ	0.9985	0.9995	1.000	
Output Resistance			0.8	2.5	Ω
Output Voltage Swing	$R_L \geq 8$ KΩ	±10			V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			dB
Negative Supply Rejection		70			dB
Input Capacitance			3.0		pF
Offset Voltage	$0°C \leq T_A \leq 70°C$			20	mV
Input Current	$T_A = 70°C$ $T_A = 0°C$		3.0 20	15 50	nA nA

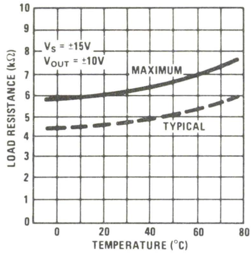
Note 1: For operating at elevated temperatures, the device must be derated based on a 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient (see curve).
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 KΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.
Note 4: These specifications apply for $T_A = 25°C$, $V_S = \pm15V$ and $C_L \leq 100$ pF unless otherwise noted.

guaranteed performance characteristics

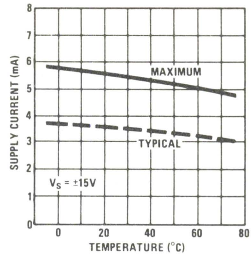
Input Current



Output Swing

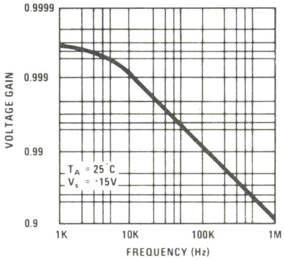


Supply Current

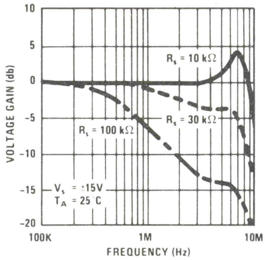


typical performance characteristics

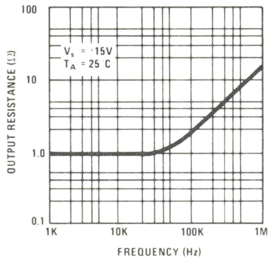
Voltage Gain



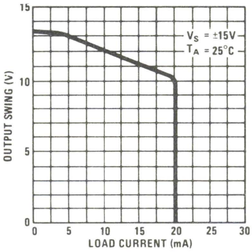
Voltage Gain



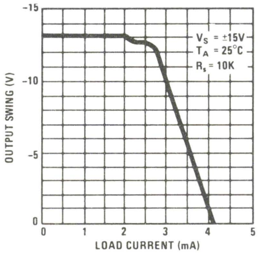
Output Resistance



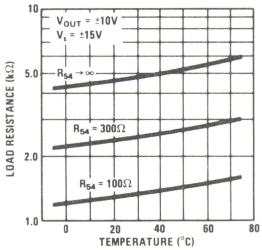
Positive Output Swing



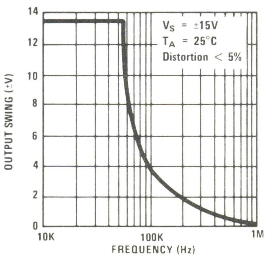
Negative Output Swing



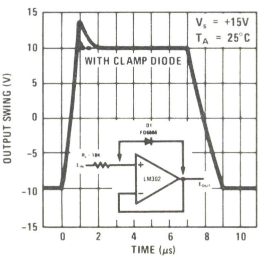
Output Swing



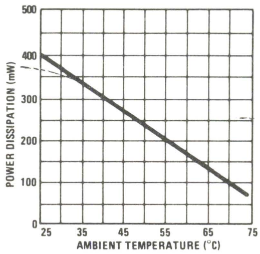
Large Signal Frequency Response



Large Signal Pulse Response



Maximum Power Dissipation



2

Operational Amplifiers

LM107/LM207 operational amplifier

general description

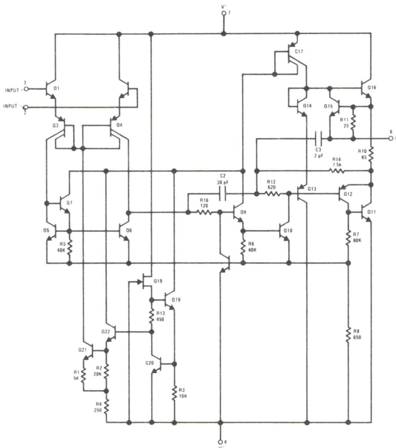
The LM107 and LM207 are complete, general purpose operational amplifiers, with the necessary frequency compensation built into the chip. Advanced processing techniques make the input currents a factor of ten lower than industry standards like the 709. Yet, they are a direct, plug-in replacement for the 709, LM101, LM101A and 741. Specifications which have been improved include:

- Offset voltage 3 mV maximum over temperature
- Input current 100 nA maximum over temperature
- Offset current 20 nA maximum over temperature
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode range

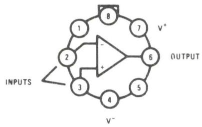
The LM107 series offers the features of the LM101, which makes its application nearly foolproof. In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

The LM207 is identical to the LM107, except that the LM207 has its performance guaranteed over a −25°C to 85°C temperature range, instead of −55°C to 125°C.

schematic** and connection diagrams



Metal Can

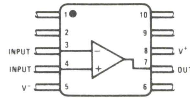


Note: Pin 4 connected to case.

TOP VIEW

Order Number LM107H or LM207H
See Package 11

Flat Package

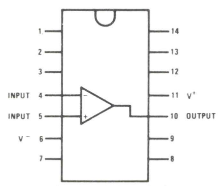


Note: Pin 5 connected to bottom of package

TOP VIEW

Order Number LM107F or LM207F
See Package 3

Dual-in-Line



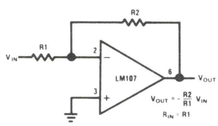
Note: Pin 6 connected to bottom of package

TOP VIEW

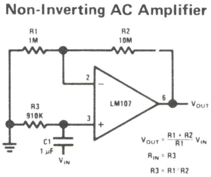
Order Number LM107D or LM207D
See Package 1

typical applications **

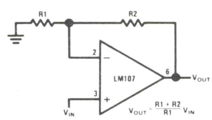
Inverting Amplifier



Non-Inverting AC Amplifier



Non-Inverting Amplifier



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM107	-55°C to 125°C
	LM207	-25°C to 85°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$		0.7	2.0	mV
Input Offset Current	$T_A = 25°C$		1.5	10	nA
Input Bias Current	$T_A = 25°C$		30	75	nA
Input Resistance	$T_A = 25°C$	1.5	4		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	µV/°C
Input Offset Current				20	nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 125°C$ $-55°C \leq T_A \leq 25°C$		0.01 0.02	0.1 0.2	nA/°C nA/°C
Input Bias Current				100	nA
Supply Current	$T_A = +125°C$, $V_S = \pm 20V$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 20V$	±15			V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	80	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	80	96		dB

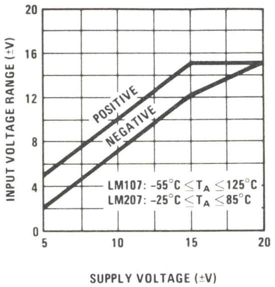
Note 1: The maximum junction temperature of the LM107 is 150°C, while that of the LM207 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

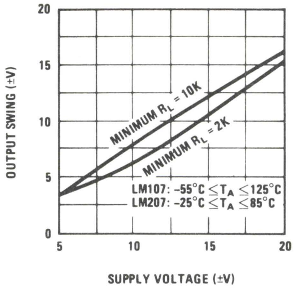
Note 3: These specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C \leq T_A \leq 125°C$ for the LM107 or $-25°C \leq T_A \leq 85°C$ for the LM207, unless otherwise specified.

guaranteed performance characteristics

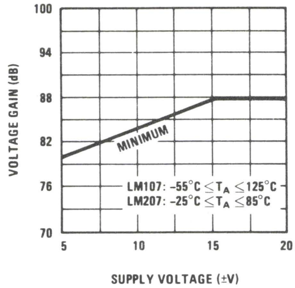
Input Voltage Range



Output Swing

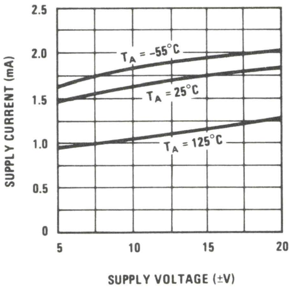


Voltage Gain

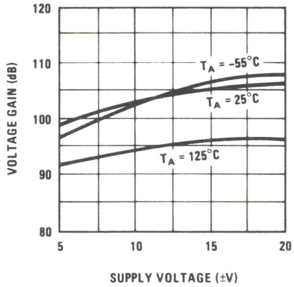


typical performance characteristics

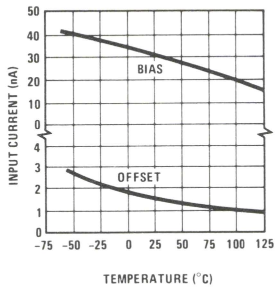
Supply Current



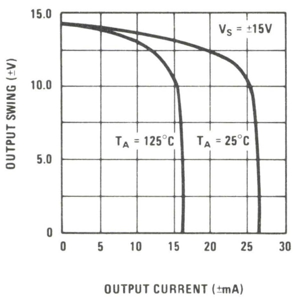
Voltage Gain



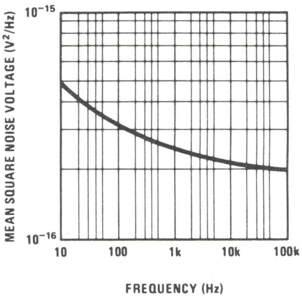
Input Current



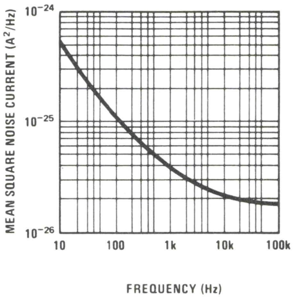
Current Limiting



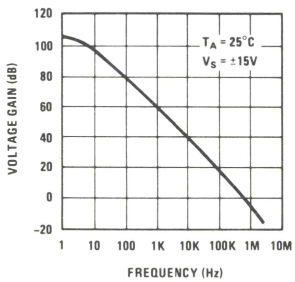
Input Noise Voltage



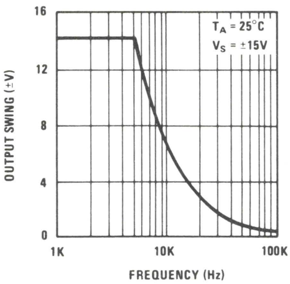
Input Noise Current



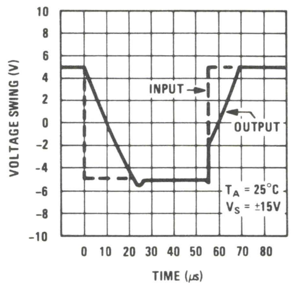
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM307 operational amplifier

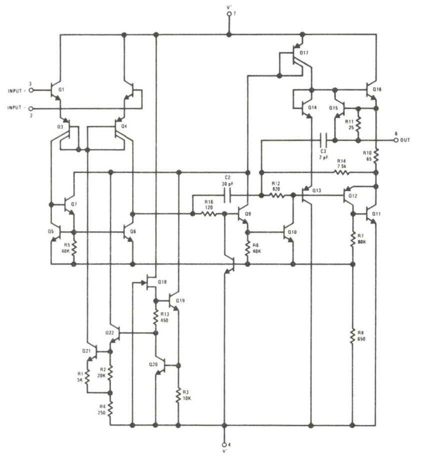
general description

The LM307 is a complete, general purpose operational amplifier, with the necessary frequency compensation built into the chip. Advanced processing techniques make the input currents a factor of ten lower than industry standards like the 709C. Yet, it is a direct, plug-in replacement for the 709C, LM201, MC1439 and 741 in most applications.

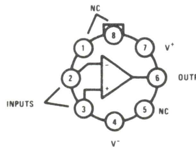
In addition to reduced input current, the offset voltage and offset current are guaranteed over the entire common mode range and maximum drift specifications are given. The amplifier also offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM307 provides better accuracy and lower noise than its predecessors in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at reduced cost.

schematic** and connection diagrams



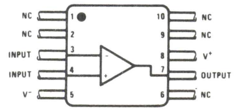
Metal Can



NOTE: Pin 4 connected to case.
TOP VIEW

Order Number LM307H
See Package 11

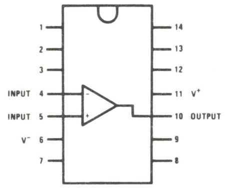
Flat Package



NOTE: Pin 5 connected to bottom of package.
TOP VIEW

Order Number LM307F
See Package 3

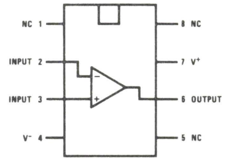
Cavity Dual-In-Line Package



NOTE: Pin 6 connected to bottom of package.
TOP VIEW

Order Number LM307D
See Package 1

Molded Dual-In-Line Package

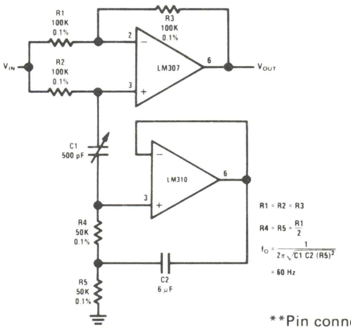


NOTE: Pin 4 connected to bottom of package.
TOP VIEW

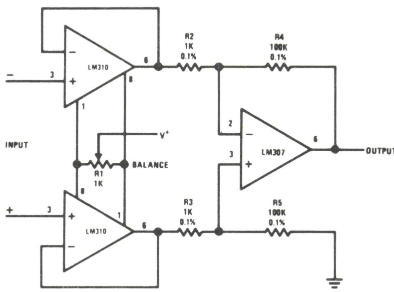
Order Number LM307N
See Package 20

typical applications**

Tunable Notch Filter



Differential Input Instrumentation Amplifier



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		3	50	nA
Input Bias Current	$T_A = 25°C$		70	250	nA
Input Resistance	$T_A = 25°C$	0.5	2		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	25	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	μV/°C
Input Offset Current				70	nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 70°C$ $0°C \leq T_A \leq 25°C$		0.01 0.02	0.3 0.6	nA/°C nA/°C
Input Bias Current				300	nA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	70	96		dB

Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.

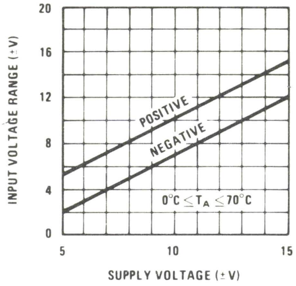
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

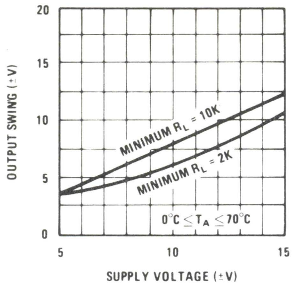
Note 4: The specifications apply for $0°C \leq T_A \leq 70°C$ and $\pm 5V \leq V_S \leq \pm 15V$, unless otherwise specified.

guaranteed performance characteristics

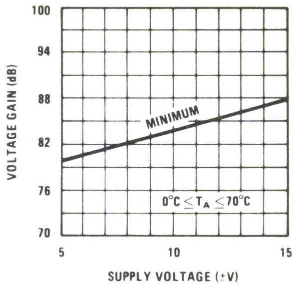
Input Voltage Range



Output Swing

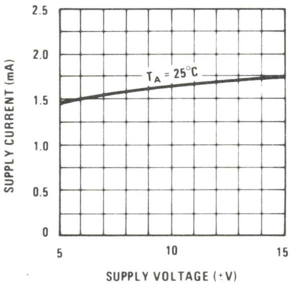


Voltage Gain

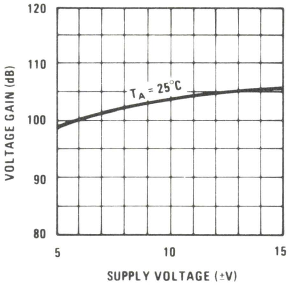


typical performance characteristics

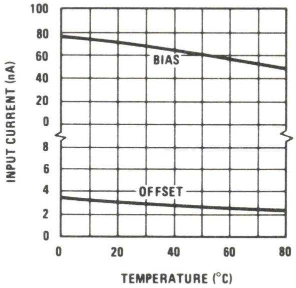
Supply Current



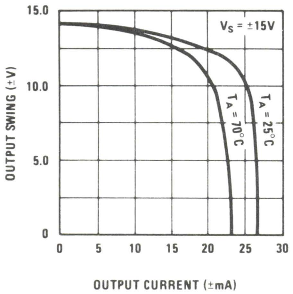
Voltage Gain



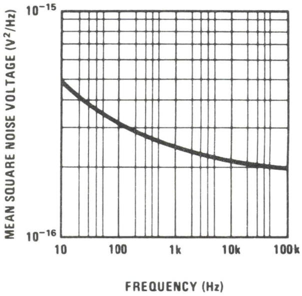
Input Current



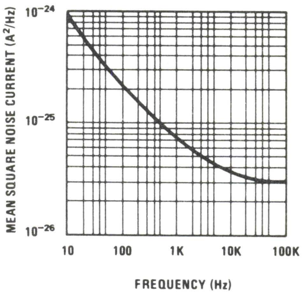
Current Limiting



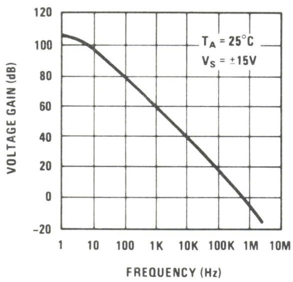
Input Noise Voltage



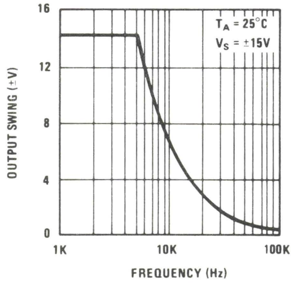
Input Noise Current



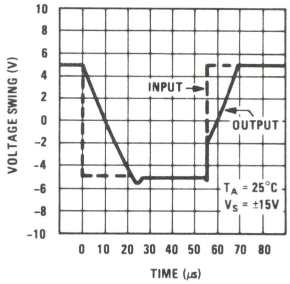
Open Loop
Frequency Response



Large Signal
Frequency Response



Voltage Follower
Pulse Response



Operational Amplifiers

LM108/LM208 operational amplifier

general description

The LM108 and LM208 are precision operational amplifiers having specifications a factor of ten better than FET amplifiers over a −55°C to 125°C temperature range. Selected units are available with offset voltages less than 1.0 mV and drifts less than 5 μV/°C, again over the military temperature range. This makes it possible to eliminate offset adjustments, in most cases, and obtain performance approaching chopper stabilized amplifiers.

The devices operate with supply voltages from ±2V to ±20V and have sufficient supply rejection to use unregulated supplies. Although the circuit is interchangeable with and uses the same compensation as the LM101A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Outstanding characteristics include:

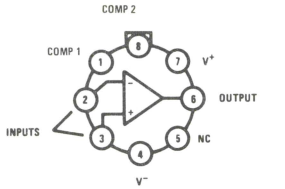
- Maximum input bias current of 3.0 nA over temperature
- Offset current less than 400 pA over temperature
- Supply current of only 300 μA, even in saturation
- Guaranteed drift characteristics

The low current error of the LM108 series makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 MΩ source resistances, introducing less error than devices like the 709 with 10 kΩ sources. Integrators with drifts less than 500 μV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF.

The LM208 is identical to the LM108, except that the LM208 has its performance guaranteed over a −25°C to 85°C temperature range, instead of −55°C to 125°C.

connection diagrams *

Metal Can



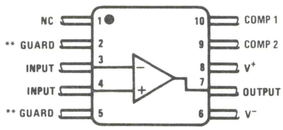
NOTE: Pin 4 connected to case.

*Pin connections shown on schematic diagram are for TO-5 package.

**Unused pin (no internal connection) to allow for input anti-leakage guard ring on printed circuit board layout

Order Number LM108H or LM208H
See Package 11

Flat Package

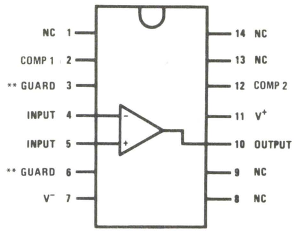


NOTE: Pin 6 connected to bottom of package

TOP VIEW

Order Number LM108F or LM208F
See Package 3

Dual-In-Line

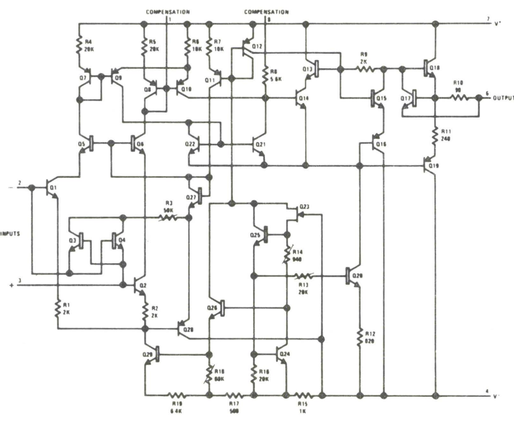


NOTE: Pin 7 connected to bottom of package

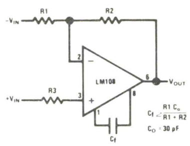
TOP VIEW

Order Number LM108D or LM208D
See Package 1

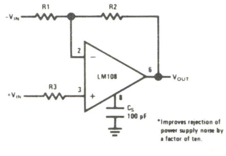
schematic diagram* and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



absolute maximum ratings

Supply Voltage		±20V
Power Dissipation (Note 1)		500 mW
Differential Input Current (Note 2)		±10 mA
Input Voltage (Note 3)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM108	−55°C to 125°C
	LM208	−25°C to 85°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 5)	$T_A = 25°C$		0.7	2.0	mV
Input Offset Current	$T_A = 25°C$		0.05	0.2	nA
Input Bias Current	$T_A = 25°C$		0.8	2.0	nA
Input Resistance	$T_A = 25°C$	30	70		MΩ
Supply Current	$T_A = 25°C$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	50	300		V/mV
Input Offset Voltage (Note 5)				3.0	mV
Average Temperature Coefficient of Input Offset Voltage (Note 5)			3.0	15	μV/°C
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	pA/°C
Input Bias Current				3.0	nA
Supply Current	$T_A = +125°C$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm15V$	±13.5			V
Common Mode Rejection Ratio		85	100		dB
Supply Voltage Rejection Ratio		80	96		dB

Note 1: The maximum junction temperature of the LM108 is 150°C, while that of the LM208 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

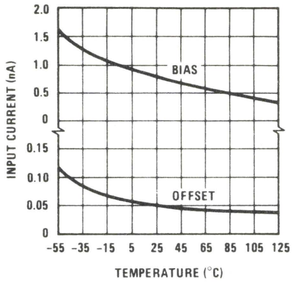
Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM208, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$.

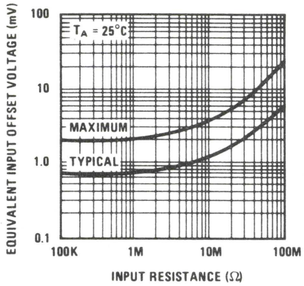
Note 5: The LM108A has a guaranteed offset voltage less than 0.5 mV at 25°C and 1.0 mV for $-55°C \leq T_A \leq 125°C$ and $V_S = \pm15V$. The average temperature coefficient of input offset voltage is guaranteed to be less than 5 μV/°C for these same conditions.

typical performance characteristics

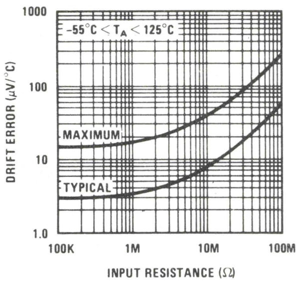
Input Currents



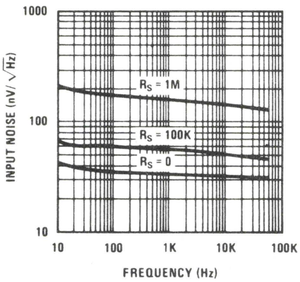
Offset Error



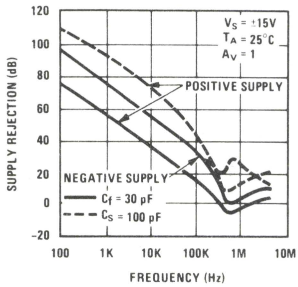
Drift Error



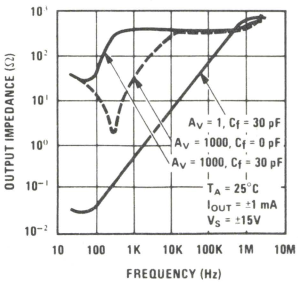
Input Noise Voltage



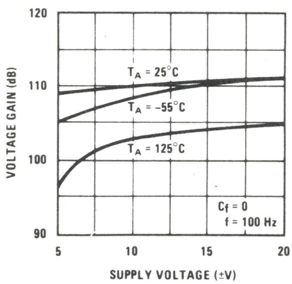
Power Supply Rejection



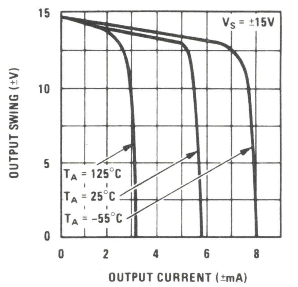
Closed Loop Output Impedance



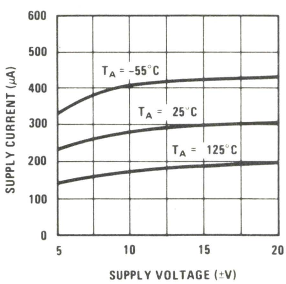
Voltage Gain



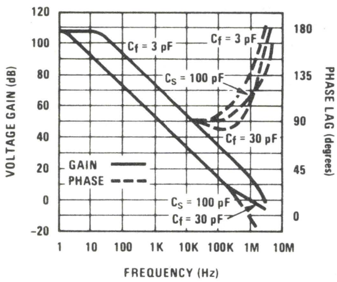
Output Swing



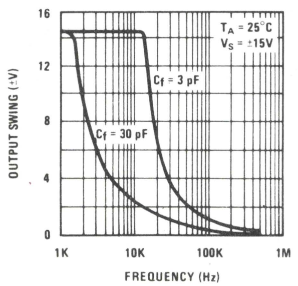
Supply Current



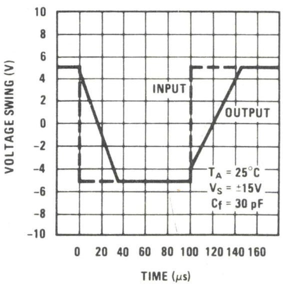
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM308 operational amplifier

general description

The LM308 is a precision operational amplifier featuring input currents nearly a thousand times lower than industry standards like the LM709C. In fact, its performance approaches that of high quality FET amplifiers. The circuit is directly interchangeable with the LM301A in low frequency circuits and incorporates the same protective features which make its application nearly foolproof.

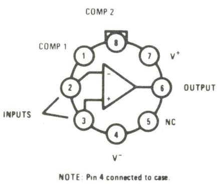
The device operates with supply voltages from ±2V to ±15V and has sufficient supply rejection to use unregulated supplies. Although the circuit is designed to work with the standard compensation for the LM301A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Power consumption is extremely low, so the amplifiers are ideally suited for battery powered applications. Outstanding characteristics include:

- Maximum input bias current of 7.0 nA
- Offset current less than 1.0 nA
- Supply current of only 300 μA, even in saturation
- Guaranteed drift characteristics

The low current error of the LM308 makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 MΩ source resistances, introducing less error than devices like the 709C with 10 kΩ sources. Integrators with worst case drifts less than 1 mV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF. The device is well suited for use with piezoelectric, electrostatic or other capacitive transducers, in addition to low frequency active filters with small capacitor values.

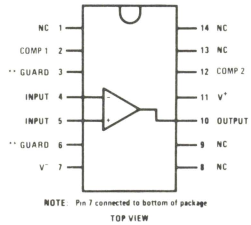
connection diagrams *

Metal Can Package



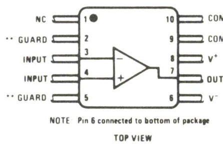
Order Number LM308H
See Package 11

Dual-In-Line Package



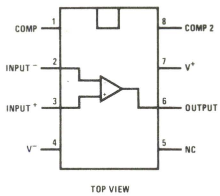
Order Number LM308D
See Package 1

Flat Package



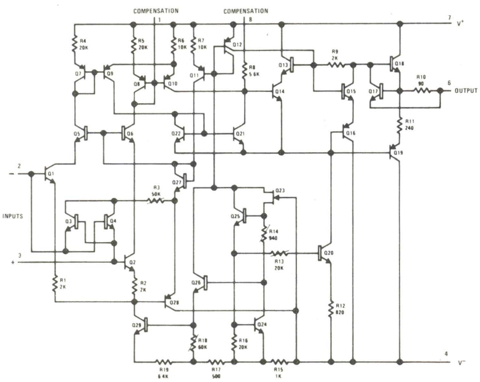
Order Number LM308F
See Package 3

Dual-In-Line Package

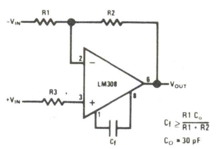


Order Number LM308N
See Package 20.

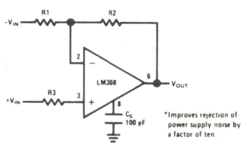
schematic diagram* and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		0.2	1	nA
Input Bias Current	$T_A = 25°C$		1.5	7	nA
Input Resistance	$T_A = 25°C$	10	40		MΩ
Supply Current	$T_A = 25°C$, $V_S = ±15V$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = ±15V$ $V_{OUT} = ±10V$, $R_L \geq 10\ k\Omega$	25	300		V/mV
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	μV/°C
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	pA/°C
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = ±15V$, $V_{OUT} = ±10V$ $R_L \geq 10\ k\Omega$	15			V/mV
Output Voltage Swing	$V_S = ±15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = ±15V$	±14			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		80	96		dB

Note 1: The maximum junction temperature of the LM308 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

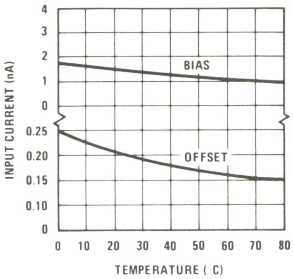
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

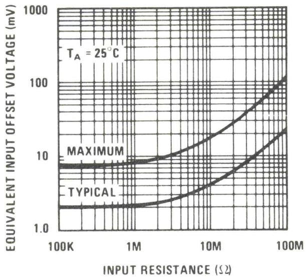
Note 4: These specifications apply for $±5V \leq V_S \leq ±15V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified.

typical performance characteristics

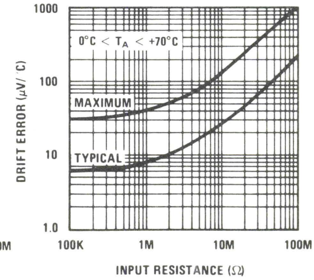
Input Currents



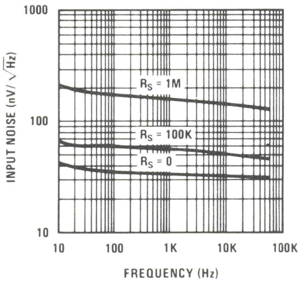
Offset Error



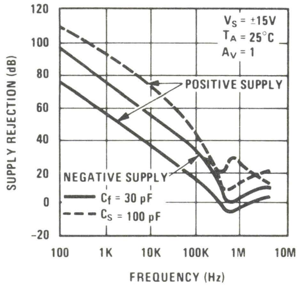
Drift Error



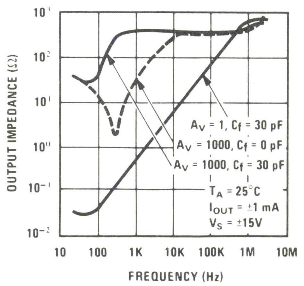
Input Noise Voltage



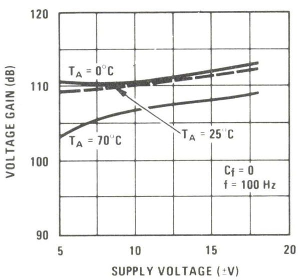
Power Supply Rejection



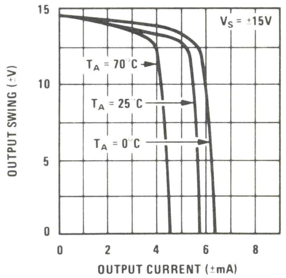
Closed Loop Output Impedance



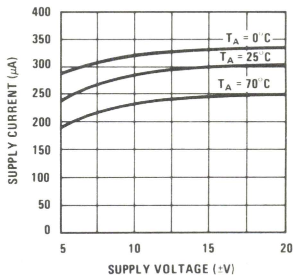
Voltage Gain



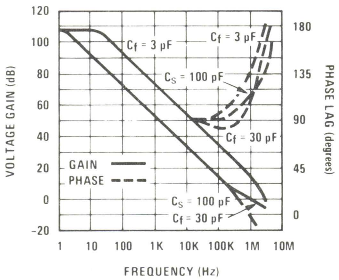
Output Swing



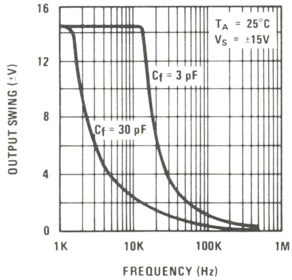
Supply Current



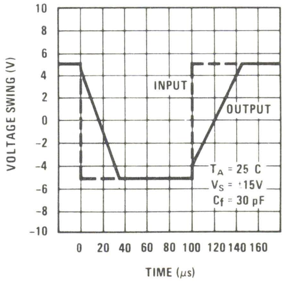
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



LM108A/LM208A/LM308A

Operational Amplifiers

LM108A/LM208A/LM308A operational amplifier

general description

The LM108A, LM208A and LM308A are precision operational amplifiers having specifications about a factor of ten better than FET amplifiers over their operating temperature range. In addition to low input currents, these devices have extremely low offset voltage, making it possible to eliminate offset adjustments, in most cases, and obtain performance approaching chopper stabilized amplifiers.

The devices operate with supply voltages from ±2V to ±20V and have sufficient supply rejection to use unregulated supplies. Although the circuit is interchangeable with and uses the same compensation as the LM101A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Outstanding characteristics include:

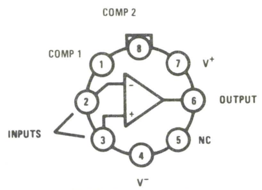
- Offset voltage guaranteed less than 0.5 mV
- Maximum input bias current of 3.0 nA over temperature
- Offset current less than 400 pA over temperature
- Supply current of only 300 μA, even in saturation
- Guaranteed 5 μV/°C drift.

The low current error of the LM108A series makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 MΩ source resistances, introducing less error than devices like the 709 with 10 kΩ sources. Integrators with drifts less than 500 μV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF.

The LM208A is identical to the LM108A, except that the LM208A has its performance guaranteed over a −25°C to 85°C temperature range, instead of −55°C to 125°C. The LM308A has slightly-relaxed specifications and has its performance guaranteed over a 0°C to 70°C temperature range.

connection diagrams *

Metal Can



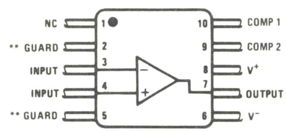
NOTE: Pin 4 connected to case.

*Pin connections shown on schematic diagram are for TO-5 package.

**Unused pin (no internal connection) to allow for input anti-leakage guard ring on printed circuit board layout

Order Number LM108AH or LM208AH or LM308AH
See Package 11

Flat Package

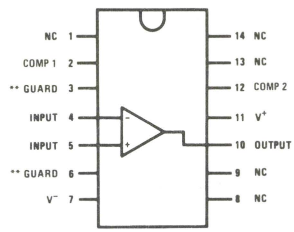


NOTE: Pin 6 connected to bottom of package.

TOP VIEW

Order Number LM108AF or LM208AF or LM308AF
See Package 3

Dual-In-Line

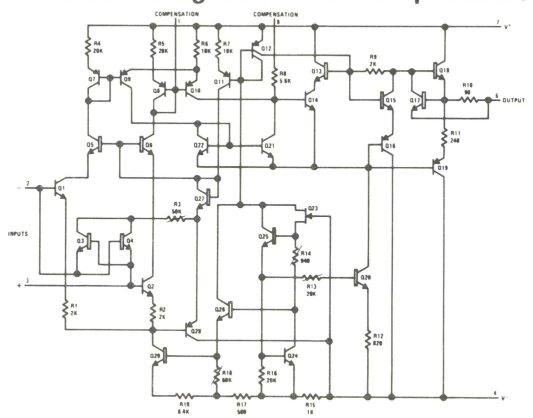


NOTE: Pin 7 connected to bottom package.

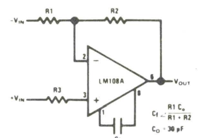
TOP VIEW

Order Number LM108AD or LM208AD or LM308AD
See Package 1

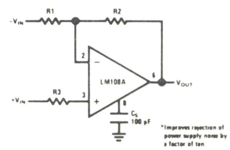
schematic diagram * and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



LM108A/LM208A

absolute maximum ratings

Supply Voltage		±20V
Power Dissipation (Note 1)		500 mW
Differential Input Current (Note 2)		±10 mA
Input Voltage (Note 3)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM108A	−55°C to 125°C
	LM208A	−25°C to 85°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		0.3	0.5	mV
Input Offset Current	$T_A = 25°C$		0.05	0.2	nA
Input Bias Current	$T_A = 25°C$		0.8	2.0	nA
Input Resistance	$T_A = 25°C$	30	70		MΩ
Supply Current	$T_A = 25°C$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	80	300		V/mV
Input Offset Voltage				1.0	mV
Average Temperature Coefficient of Input Offset Voltage			1.0	5.0	μV/°C
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	pA/°C
Input Bias Current				3.0	nA
Supply Current	$T_A = +125°C$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	40			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm15V$	±13.5			V
Common Mode Rejection Ratio		96	110		dB
Supply Voltage Rejection Ratio		96	110		dB

Note 1: The maximum junction temperature of the LM108A is 150°C, while that of the LM208A is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM208A, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$.

2

LM308A

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	–65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		0.3	0.5	mV
Input Offset Current	$T_A = 25°C$		0.2	1	nA
Input Bias Current	$T_A = 25°C$		1.5	7	nA
Input Resistance	$T_A = 25°C$	10	40		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 10\ k\Omega$	80	300		V/mV
Input Offset Voltage				0.73	mV
Average Temperature Coefficient of Input Offset Voltage			1.0	5.0	μV/°C
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	pA/°C
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 10\ k\Omega$	60			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15V$	±14			V
Common Mode Rejection Ratio		96	110		dB
Supply Voltage Rejection Ratio		96	110		dB

Note 1: The maximum junction temperature of the LM308A is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5V \leq V_S \leq \pm 15V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified.

Operational Amplifiers

LM110/LM210 voltage follower

general description

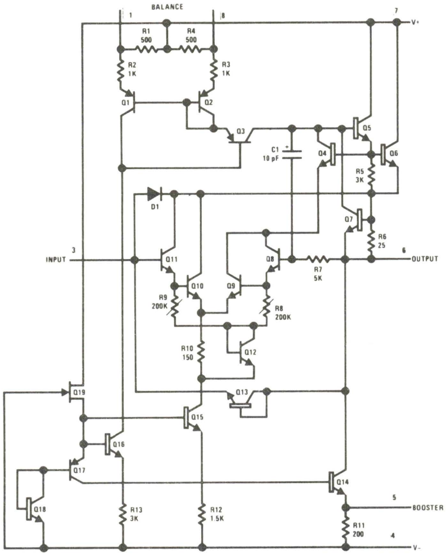
The LM110 and LM210 are monolithic operational amplifiers internally connected as unity-gain non-inverting amplifiers. They use super-gain transistors in the input stage to get low bias current without sacrificing speed. Directly interchangeable with 101, 741 and 709 in voltage follower applications, these devices have internal frequency compensation and provision for offset balancing. Outstanding characteristics include:

- Input current: 10 nA max. over temperature
- Small signal bandwidth: 20 MHz
- Slew rate: 30V/μs
- Supply voltage range: ±5V to ±18V

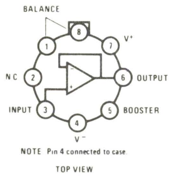
The LM110 and LM210 are useful in fast sample and hold circuits, active filters or as general-purpose buffers. Further, the frequency response is enough better than standard IC amplifiers that the followers can be included in the feedback loop without introducing instability. They are plug-in replacements for the LM102 or LM202 voltage followers, offering lower offset voltage, drift, bias current and noise in addition to higher speed and wider operating voltage range.

The LM210 is identical to the LM110, except that its performance is specified over a −25°C to 85°C temperature range instead of −55°C to 125°C.

schematic** and connection diagrams

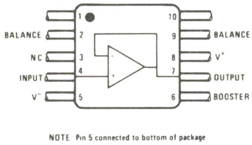


Metal Can



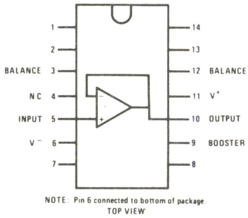
Order Number
LM110H or LM210H
See Package 11

Flat Package



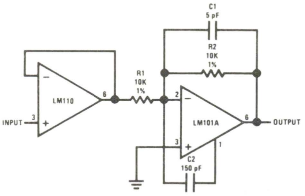
Order Number
LM110F or LM210F
See Package 3

Dual-In-Line

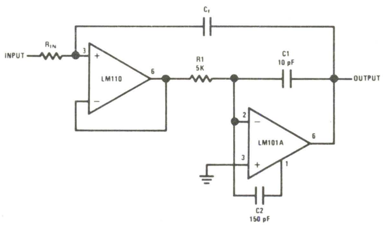


Order Number LM110D or LM210D
See Package 1

typical applications**



Fast Inverting Amplifier with High Input Impedance



Fast Integrator with Low Input Current

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage		±18V
Power Dissipation (Note 1)		500 mW
Input Voltage (Note 2)		±15V
Output Short Circuit Duration (Note 3)		Indefinite
Operating Temperature Range	LM110	–55°C to 125°C
	LM210	–25°C to 85°C
Storage Temperature Range		–65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		1.5	4.0	mV
Input Bias Current	$T_A = 25°C$		1.0	3.0	nA
Input Resistance	$T_A = 25°C$	10^{10}	10^{12}		Ω
Input Capacitance			1.5		pF
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = ±15V$ $V_{OUT} = ±10V$, $R_L = 8KΩ$	0.999	0.9997		V/V
Output Resistance	$T_A = 25°C$		0.75	2.5	Ω
Supply Current	$T_A = 25°C$		3.9	5.5	mA
Input Offset Voltage				6.0	mV
Offset Voltage Temperature Drift	$-55°C \leq T_A \leq 85°C$ $T_A = 125°C$		6 12		μV/°C μV/°C
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = ±15V$, $V_{OUT} = ±10V$ $R_L = 10KΩ$	0.999			V/V
Output Voltage Swing (Note 5)	$V_S = ±15V$, $R_L = 10KΩ$	±10			V
Supply Current	$T_A = 125°C$		2.0	4.0	mA
Supply Voltage Rejection Ratio	$±5V \leq V_S \leq ±18V$	70	80		dB

Note 1: The maximum junction temperature of the LM110 is 150°C, while that of the LM210 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

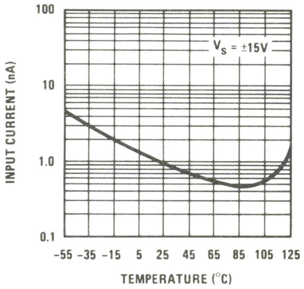
Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 70°C. It is necessary to insert a resistor greater than 2kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $±5V \leq V_S \leq ±18V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM210, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$.

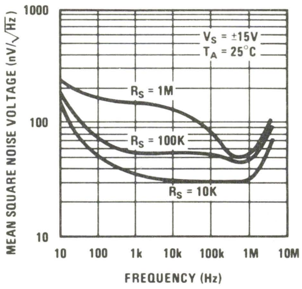
Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V^- terminals. See curve.

typical performance characteristics

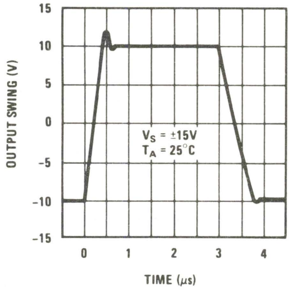
Input Current



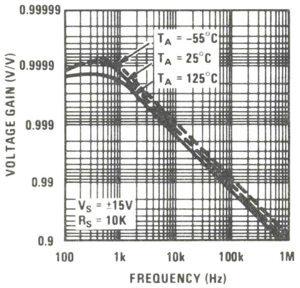
Output Noise Voltage



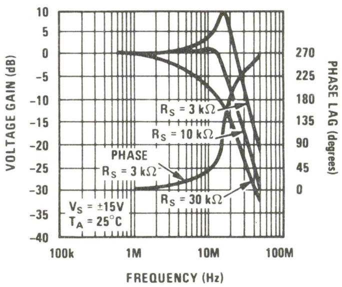
Large Signal Pulse Response



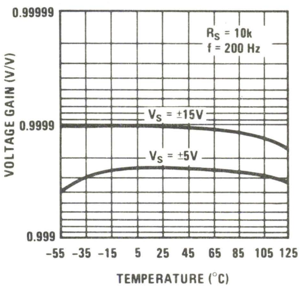
Voltage Gain



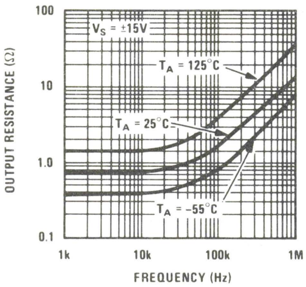
Voltage Gain



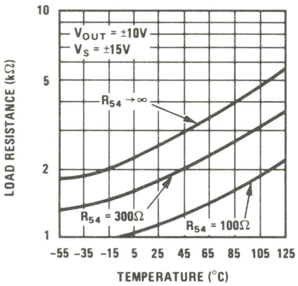
Voltage Gain



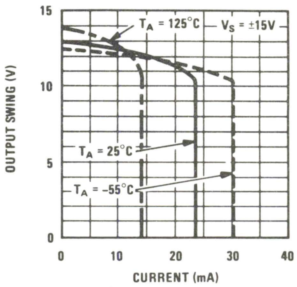
Output Resistance



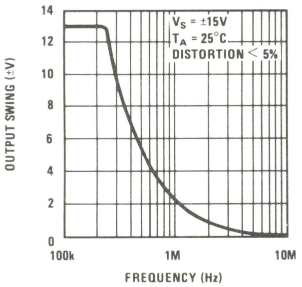
Symmetrical Output Swing



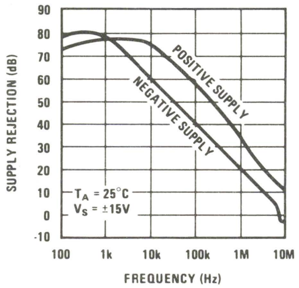
Positive Output Swing



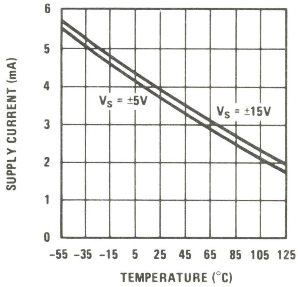
Large Signal Frequency Response



Power Supply Rejection

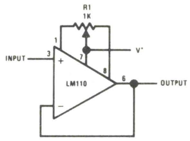


Supply Current

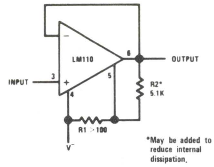


2

auxiliary circuits

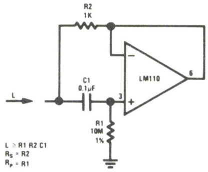


Offset Balancing Circuit

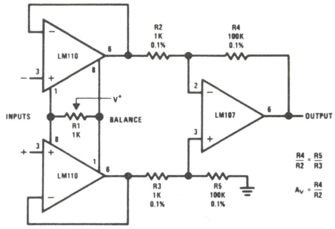


Increasing Negative Swing Under Load

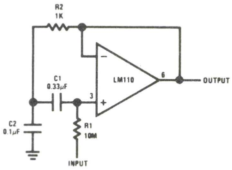
typical applications** (con't)



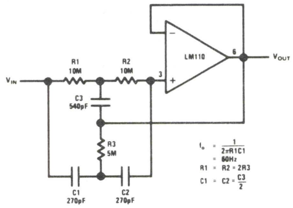
Simulated Inductor



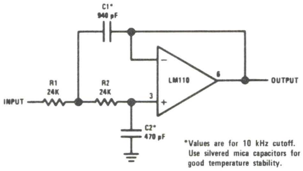
Differential Input Instrumentation Amplifier



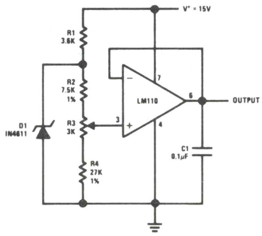
Bandpass Filter



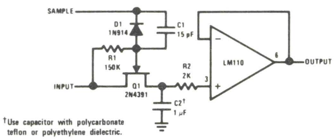
High Q Notch Filter



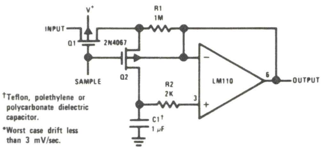
Low Pass Active Filter



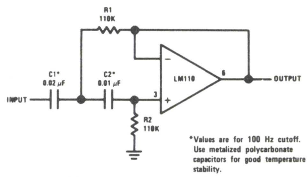
Buffered Reference Source



Sample and Hold



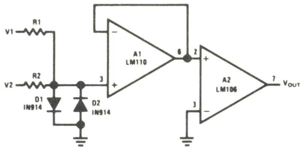
Low Drift Sample and Hold*



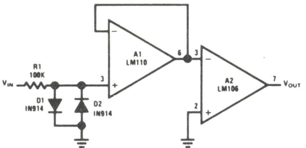
High Pass Active Filter

**Pin connections shown are for metal can.

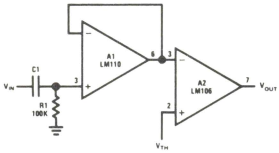
typical applications** (con't)



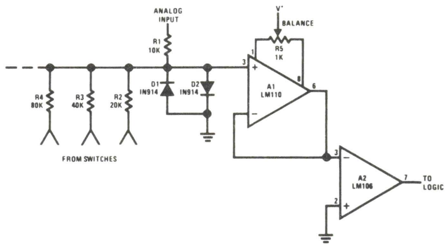
Comparator for Signals of Opposite Polarity



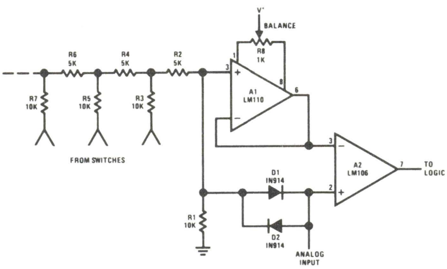
Zero Crossing Detector



Comparator for AC Coupled Signals

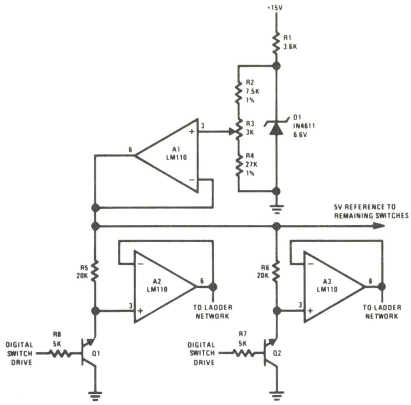


Comparator for A/D Converter
Using a Binary-Weighted Network

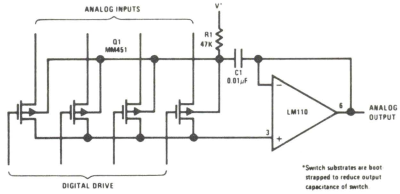


Comparator for A/D Converter
Using a Ladder Network

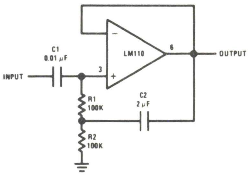
**Pin connections shown are for metal can.



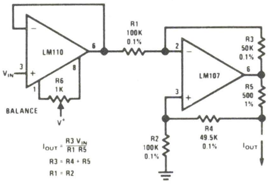
Driver for A/D Ladder Network



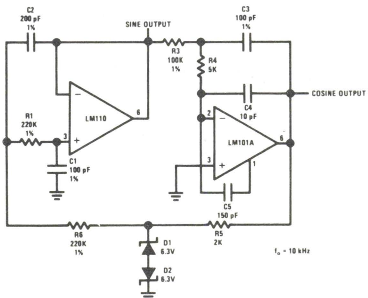
Buffer for Analog Switch*



High Input Impedance AC Amplifier



Bilateral Current Source



Sine Wave Oscillator

Operational Amplifiers

LM310 voltage follower

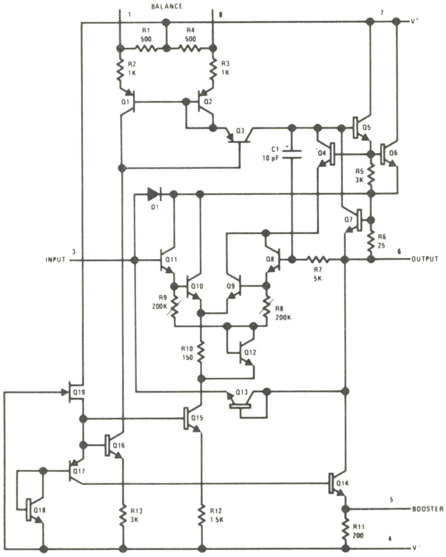
general description

The LM310 is a monolithic operational amplifier internally connected as a unity-gain non-inverting amplifier. It uses super-gain transistors in the input stage to get low bias current without sacrificing speed. Directly interchangeable with 301, 741C and 709C in voltage follower applications, this device has internal frequency compensation and provision for offset balancing. Outstanding characteristics include:

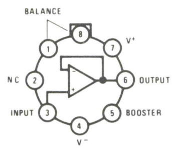
- Input current: 10 nA max. over temperature
- Small signal bandwidth: 20 MHz
- Slew rate: 30V/μs
- Supply voltage range: ±5V to ±18V

The LM310 is useful in fast sample and hold circuits, active filters or as a general-purpose buffer. Further, the frequency response is enough better than standard IC amplifiers that the follower can be included in the feedback loop without introducing instability. It is a plug-in replacement for the LM302 voltage follower, offering lower offset voltage, drift, bias current and noise in addition to higher speed and wider operating voltage range.

schematic** and connection diagrams



Metal Can

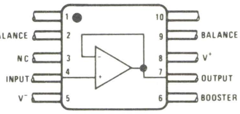


NOTE: Pin 4 connected to case.

TOP VIEW

Order Number LM310H
See Package 11

Flat Package

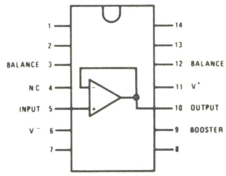


NOTE: Pin 5 connected to bottom of package.

TOP VIEW

Order Number LM310F
See Package 3

Dual-In-Line Package

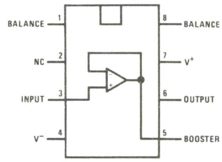


NOTE: Pin 6 connected to bottom of package.

TOP VIEW

Order Number LM310D
See Package 1

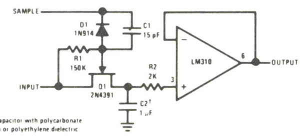
Dual-In-Line Package



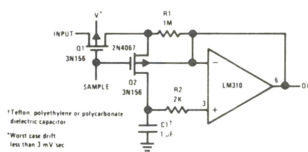
TOP VIEW

Order Number LM310N
See Package 20.

typical applications**



Sample and Hold



Low Drift Sample and Hold*

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	T_A = 25°C		2.5	7.5	mV
Input Bias Current	T_A = 25°C		2.0	7.0	nA
Input Resistance	T_A = 25°C	10^{10}	10^{12}		Ω
Input Capacitance			1.5		pF
Large Signal Voltage Gain	T_A = 25°C, V_S = ±15V V_{OUT} = ±10V, R_L = 8KΩ	0.999	0.9999		V/V
Output Resistance	T_A = 25°C		0.75	2.5	Ω
Supply Current	T_A = 25°C		3.9	5.5	mA
Input Offset Voltage				10	mV
Offset Voltage Temperature Drift			10		μV/°C
Input Bias Current				10	nA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = ±10V R_L = 10KΩ	0.999			V/V
Output Voltage Swing (Note 5)	V_S = ±15V, R_L = 10KΩ	±10			V
Supply Voltage Rejection Ratio	$\pm 5V \leq V_S \leq \pm 18V$	70	80		dB

Note 1: The maximum junction temperature of the LM310 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

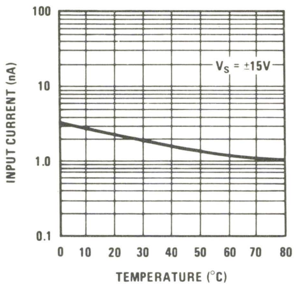
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $\pm 5V \leq V_S \leq \pm 18V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified.

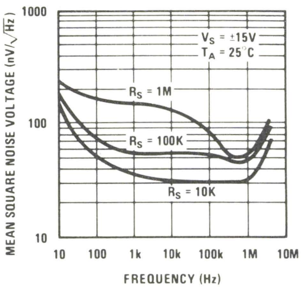
Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V^- terminals. See curve.

typical performance characteristics

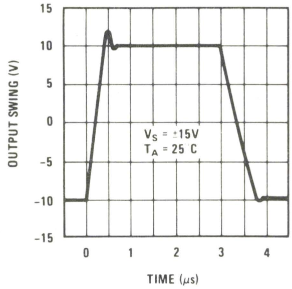
Input Current



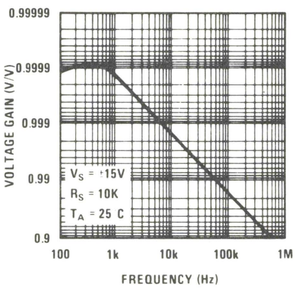
Output Noise Voltage



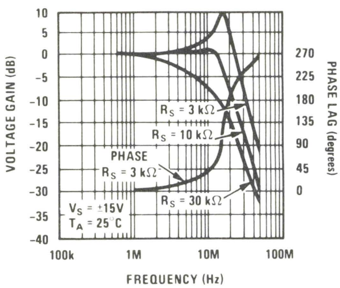
Large Signal Pulse Response



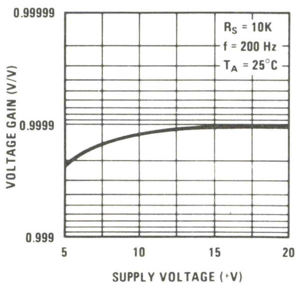
Voltage Gain



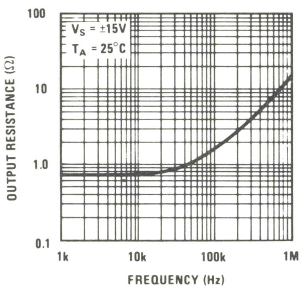
Voltage Gain



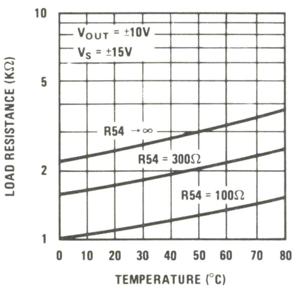
Voltage Gain



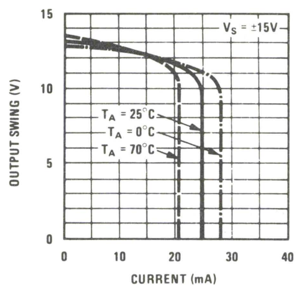
Output Resistance



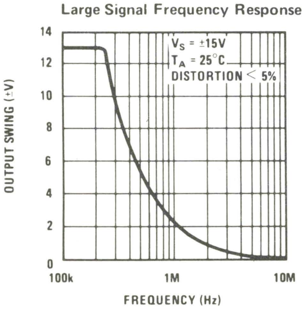
Symmetrical Output Swing



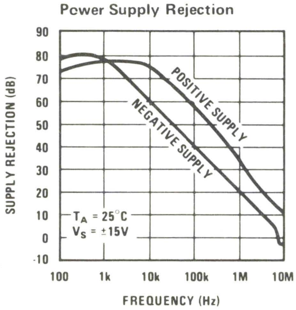
Positive Output Swing



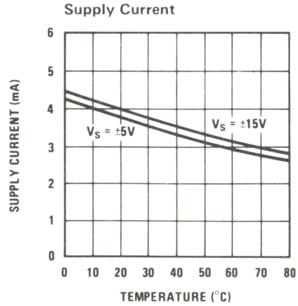
Large Signal Frequency Response



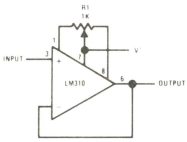
Power Supply Rejection



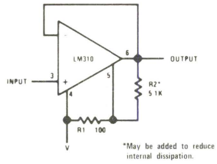
Supply Current



auxiliary circuits **

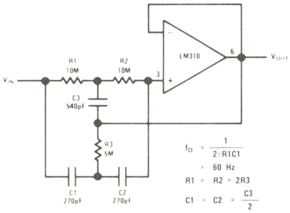


Offset Balancing Circuit



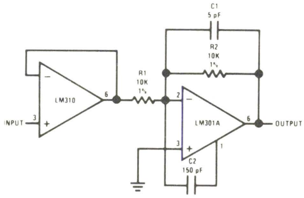
Increasing Negative Swing Under Load

typical applications** (con't)

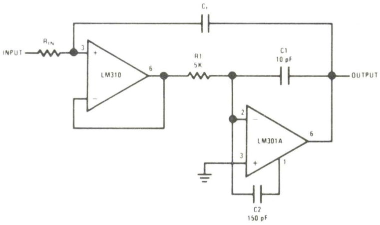


$$f_O = \frac{1}{2\pi R1C1} = 60 \text{ Hz}$$
$$R1 = R2 = 2R3$$
$$C1 = C2 = \frac{C3}{2}$$

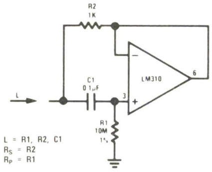
High Q Notch Filter



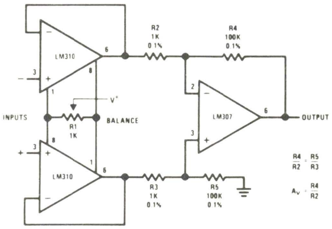
Fast Inverting Amplifier with High Input Impedance



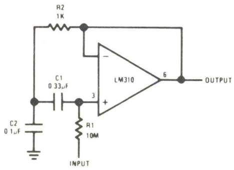
Fast Integrator with Low Input Current



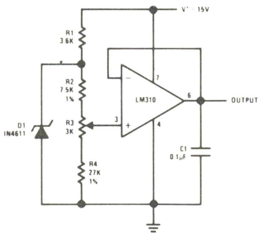
Simulated Inductor



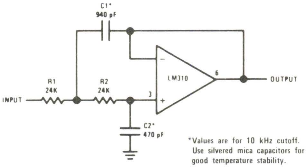
Differential Input Instrumentation Amplifier



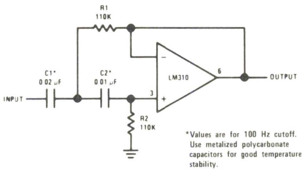
Bandpass Filter



Buffered Reference Source



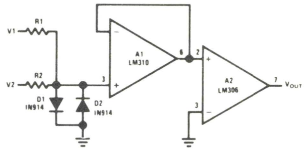
Low Pass Active Filter



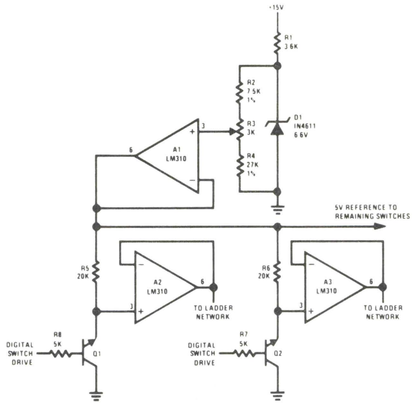
High Pass Active Filter

**Pin connections shown are for metal can.

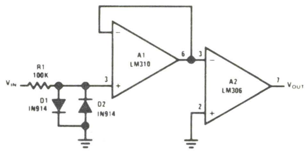
typical applications** (con't)



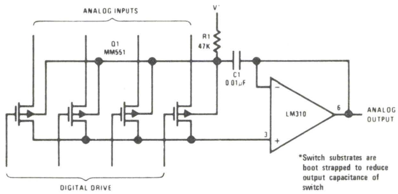
Comparator for Signals of Opposite Polarity



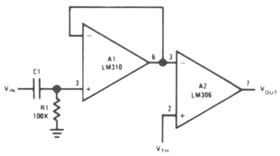
Driver for A/D Ladder Network



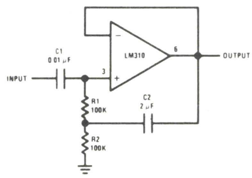
Zero Crossing Detector



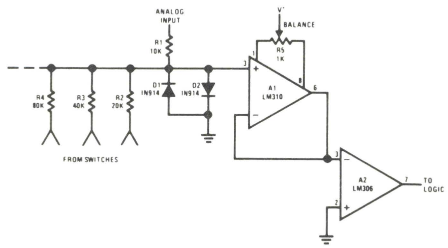
Buffer for Analog Switch*



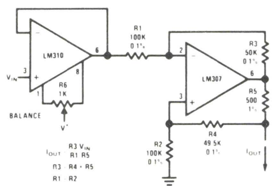
Comparator for AC Coupled Signals



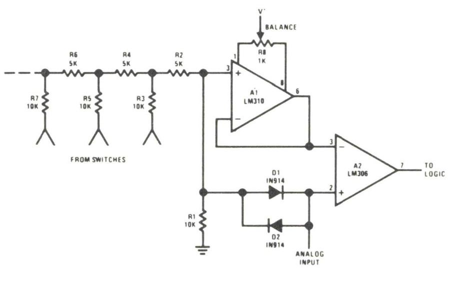
High Input Impedance AC Amplifier



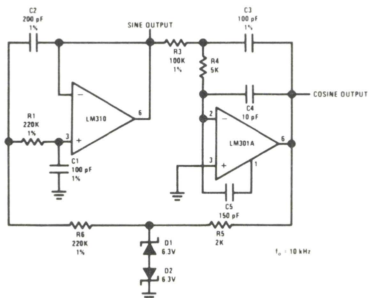
Comparator for A/D Converter
Using a Binary-Weighted Network



Bilateral Current Source



Comparator for A/D Converter
Using a Ladder Network



Sine Wave Oscillator

**Pin connections shown are for metal can.

Operational Amplifiers

LM112/LM212 operational amplifier

general description

The LM112 and LM212 are micropower operational amplifiers with very low offset-voltage and input-current errors—at least a factor of ten better than FET amplifiers over a −55°C to 125°C temperature range. Similar to the LM108 series, that also use supergain transistors,* they differ in that they include internal frequency compensation and have provisions for offset adjustment with a single potentiometer.

These amplifiers will operate on supply voltages of ±2V to ±20V, drawing a quiescent current of only 300 μA. Performance is not appreciably affected over this range of voltages, so operation from unregulated power sources is easily accomplished. They can also be run from a single supply like the 5V used for digital circuits. Some noteworthy features are:

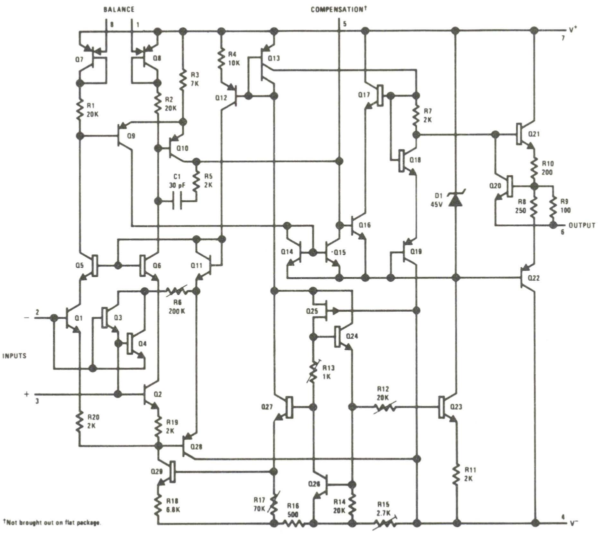
- Maximum input bias current of 3.0 nA over temperature
- Offset current less than 400 pA over temperature
- Low noise
- Guaranteed drift specifications

The LM112 series are the first IC amplifiers to improve reliability by including overvoltage protection for the MOS compensation capacitor. Without this feature, IC's have been known to suffer catastrophic failure caused by short-duration overvoltage spikes on the supplies. Unlike other internally-compensated IC amplifiers, it is possible to overcompensate with an external capacitor to increase stability margin.

The LM212 is identical to the LM112, except that the LM212 has its performance guaranteed over a −25°C to 85°C temperature range instead of −55°C to 125°C.

*Patent pending

schematic diagram**

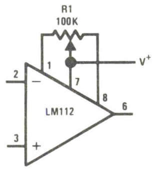


†Not brought out on flat package.

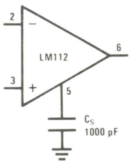
**Pin connections shown are for metal can.

auxiliary circuits**

Offset Balancing

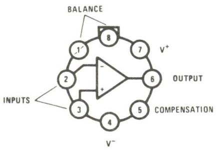


Overcompensation for Greater Stability Margin



connection diagrams

Metal Can

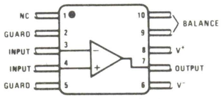


NOTE: Pin 4 connected to case.

TOP VIEW

Order Number LM112H or LM212H
See Package 11

Flat Package



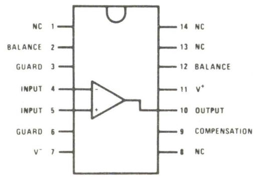
NOTE: Pin 6 connected to bottom of package.

Compensation terminal not brought out on flat package.

TOP VIEW

Order Number LM112F or LM212F
See Package 3

Dual-In-Line



NOTE: Pin 7 connected to bottom of package.

TOP VIEW

Order Number LM112D or LM212D
See Package 1

absolute maximum ratings

Supply Voltage		±20V
Power Dissipation (Note 1)		500 mW
Differential Input Current (Note 2)		±10 mA
Input Voltage (Note 3)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM112	-55°C to 125°C
	LM212	-25°C to 85°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		0.7	2.0	mV
Input Offset Current	$T_A = 25°C$		0.05	0.2	nA
Input Bias Current	$T_A = 25°C$		0.8	2.0	nA
Input Resistance	$T_A = 25°C$	30	70		MΩ
Supply Current	$T_A = 25°C$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	50	300		V/mV
Input Offset Voltage				3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	μV/°C
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	pA/°C
Input Bias Current				3.0	nA
Supply Current	$T_A = +125°C$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm15V$	±13.5			V
Common Mode Rejection Ratio		85	100		dB
Supply Voltage Rejection Ratio		80	96		dB

Note 1: The maximum junction temperature of the LM112 is 150°C, while that of the LM212 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

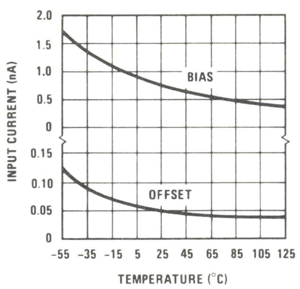
Note 2: The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

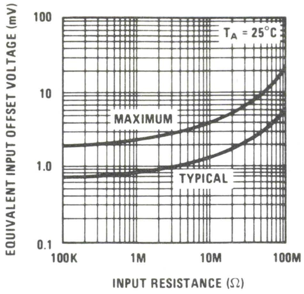
Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM212, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$.

typical performance characteristics

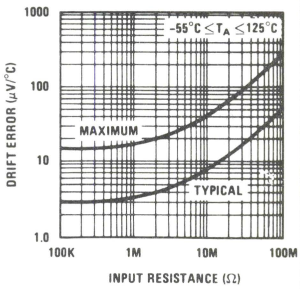
Input Currents



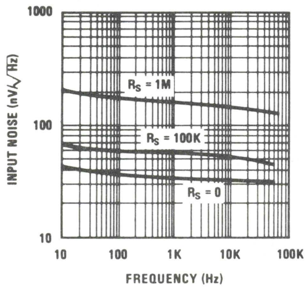
Offset Error



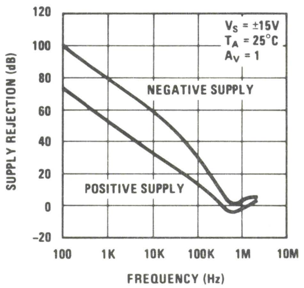
Drift Error



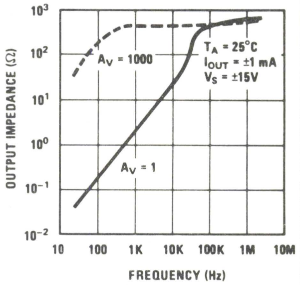
Input Noise Voltage



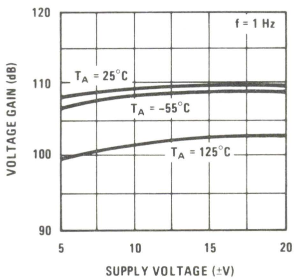
Power Supply Rejection



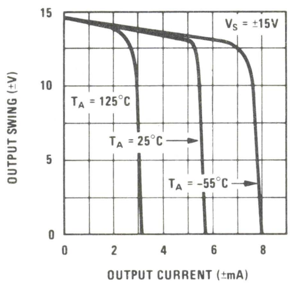
Closed Loop Output Impedance



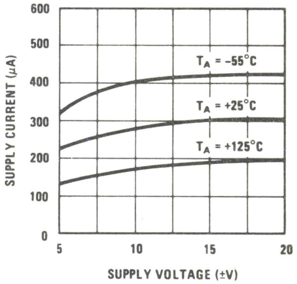
Voltage Gain



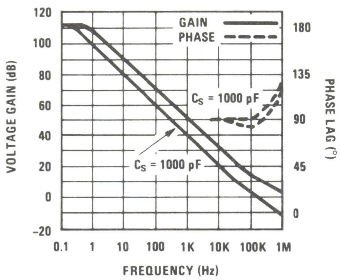
Output Swing



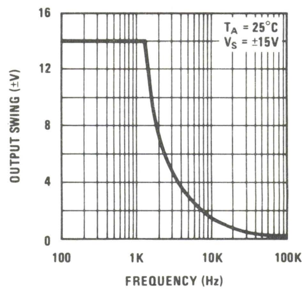
Supply Current



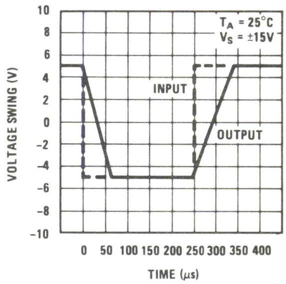
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



2

Operational Amplifiers

LM312 operational amplifier

general description

The LM312 is a micropower operational amplifier with very low offset voltage and input-current errors—approaching that of FET amplifiers over its operating temperature range. Similar to the LM308 series, that also uses supergain transistors†, it differs in that it includes internal frequency compensation and has provisions for offset adjustment with a single potentiometer.

This amplifier will operate on supply voltages of ±2V to ±20V, drawing a quiescent current of only 300 μA. Performance is not appreciably affected over this range of voltages, so operation from unregulated power sources is easily accomplished. It can also be run from a single supply like the 5V used for digital circuits. Some noteworthy features are:

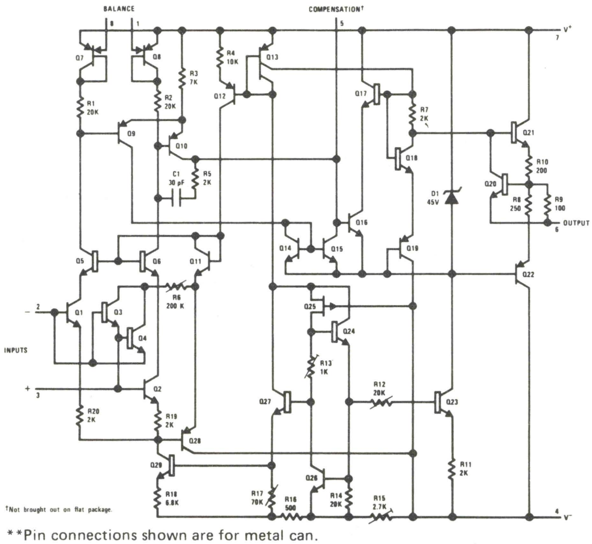
- Maximum input bias current of 7.0 nA
- Offset current less than 1.0 nA
- Low noise
- Guaranteed drift specifications

The LM312 series is the first IC amplifier to improve reliability by including overvoltage protection for the MOS compensation capacitor. Without this feature, IC's have been known to be sensitive to catastrophic failure caused by short-duration overvoltage spikes on the supplies. Unlike other internally-compensated IC amplifiers, it is possible to overcompensate with an external capacitor to increase stability margin.

The low current error of the LM312 makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 MΩ source resistances, introducing less error than devices like the 709C with 10 kΩ sources. Integrators with worst case drifts less than 1 mV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF. The device is well suited for use with piezo-electric, electrostatic or other capacitive tranducers, in addition to low frequency active filters with small capacitor values.

†Patent pending

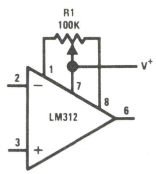
schematic diagram**



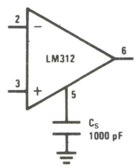
**Pin connections shown are for metal can.

auxiliary circuits**

Offset Balancing

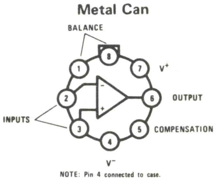


Overcompensation for Greater Stability Margin



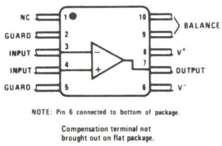
connection diagrams

Metal Can



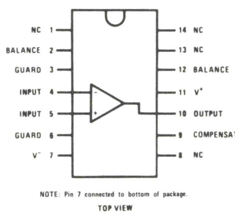
Order Number LM312H
See Package 11

Flat Package



Order Number LM312F
See Package 3

Dual-In-Line



Order Number LM312D
See Package 1

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		0.2	1	nA
Input Bias Current	$T_A = 25°C$		1.5	7	nA
Input Resistance	$T_A = 25°C$	10	40		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm15V$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	25	300		V/mV
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	μV/°C
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	pA/°C
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm15V$	±14			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		80	96		dB

Note 1: The maximum junction temperature of the LM312 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

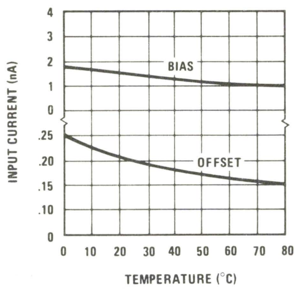
Note 2: The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

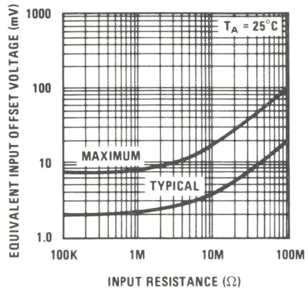
Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm15V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified.

typical performance characteristics

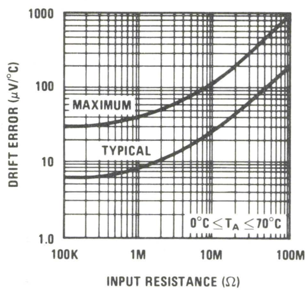
Input Currents



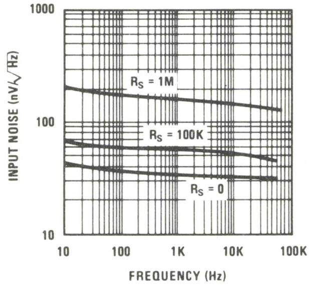
Offset Error



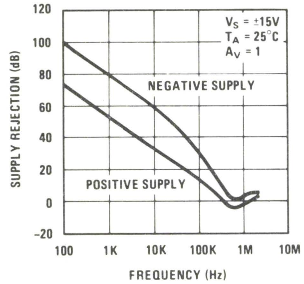
Drift Error



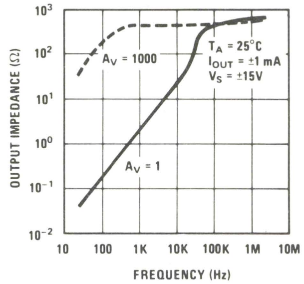
Input Noise Voltage



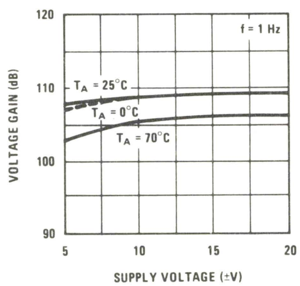
Power Supply Rejection



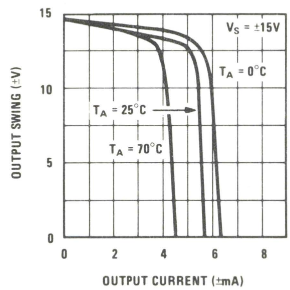
Closed Loop Output Impedance



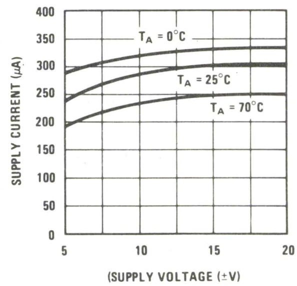
Voltage Gain



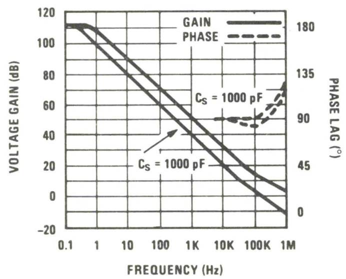
Output Swing



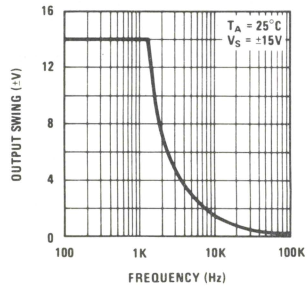
Supply Current



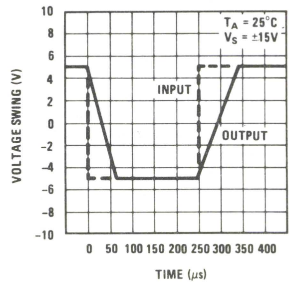
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM216/LM216A/LM316/LM316A operational amplifier

general description

These devices are precision, high input impedance operational amplifiers designed for applications requiring extremely low input-current errors. They use supergain transistors in a Darlington input stage to get input bias currents that are equal to high-quality FET amplifiers—even in limited temperature range operation. The low input current is, however, obtained with some sacrifice to offset voltage, offset voltage drift and noise when compared to the non-Darlington LM112 series. Noteworthy specifications include:

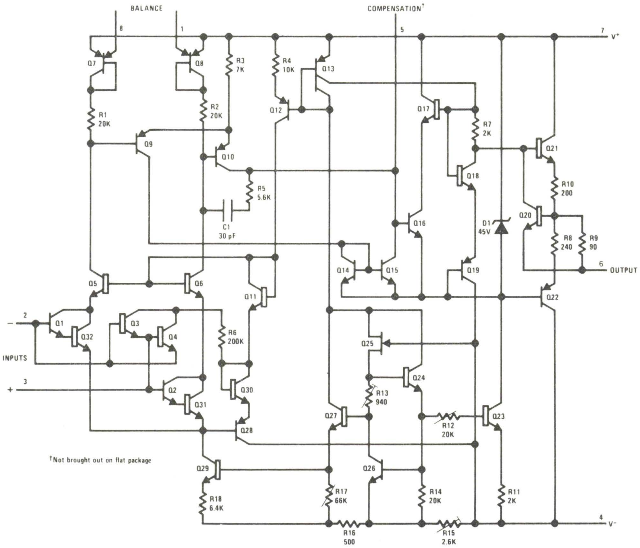
- Guaranteed bias currents as low as 50 pA
- Maximum offset currents down to 15 pA
- Operates from supplies of ±3V to ±20V
- Supply current only 300 μA at ±20V

These operational amplifiers are internally frequency compensated and have provisions for offset balancing with a single external potentiometer. Further, unlike most other internally compensated amplifiers, the MOS compensation capacitor is protected to prevent catastrophic failure from overvoltage spikes on the supplies.

The low current error of these amplifiers make possible many designs that were previously impractical with monolithic amplifiers. They will operate from 100 MΩ source resistances, introducing less error than general purpose amplifiers with 10 kΩ sources. Integrators with worst case drifts less than 10 μV/sec and analog time delays in excess of one day can also be made using capacitors no larger than 1 μF.

The LM216A and LM316A are high performance versions of the LM216 and LM316. The LM216 and LM216A are specified for operation from −25°C to 85°C, while the LM316 and LM316A are specified from 0°C to 55°C.

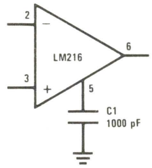
schematic diagram



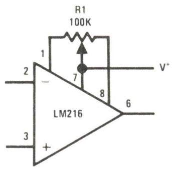
**Pin connections shown are for metal can.

auxiliary circuits**

Overcompensation for Greater Stability Margin

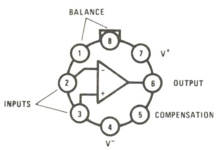


Offset Balancing



connection diagrams

Metal Can

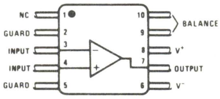


NOTE: Pin 4 connected to case.

TOP VIEW

Order Number LM216H or LM216AH or LM316H or LM316AH
See Package 11

Flat Package



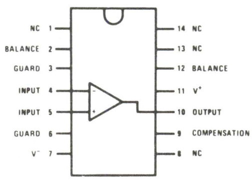
NOTE: Pin 6 connected to bottom of package.

Compensation terminal not brought out on flat package.

TOP VIEW

Order Number LM216F or LM216AF or LM316F or LM316AF
See Package 3

Dual-In-Line



NOTE: Pin 7 connected to bottom of package.

TOP VIEW

Order Number LM216D or LM216AD or LM316D or LM316AD
See Package 1

absolute maximum ratings

Supply Voltage		±20V
Power Dissipation (Note 1)		500 mW
Differential Input Current (Note 2)		±10 mA
Input Voltage (Note 3)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM216/LM216A	−25°C to 85°C
	LM316/LM316A	0°C to 70°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	LM216	LM216A	LM316	LM316A	UNITS
Input Offset Voltage	$T_A = 25°C$	10	3	10	3	mV
Input Offset Current	$T_A = 25°C$	50	15	50	15	pA
Input Bias Current	$T_A = 25°C$	150	50	150	50	pA
Input Resistance	$T_A = 25°C$	1	5	1	5	GΩ
Supply Current	$T_A = 25°C$	0.8	0.6	0.8	0.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = ±15V$ $V_{OUT} = ±10V$, $R_L \geq 10\ k\Omega$	20	40	20	40	V/mV
Input Offset Voltage		15	6	15	6	mV
Input Offset Current		100	30	100	30	pA
Input Bias Current		250	100	250	100	pA
Supply Current	$T_A = T_{MAX}$		0.5		0.5	mA
Large Signal Voltage Gain	$V_S = ±15V$, $V_{OUT} = ±10V$ $R_L \geq 10\ k\Omega$	10	20	15	30	V/mV
Output Voltage Swing	$V_S = ±15V$, $R_L = 10\ k\Omega$	±13	±13	±13	±13	V
Input Voltage Range	$V_S = ±15V$	±13	±13	±13	±13	V
Common Mode Rejection Ratio		80	80	80	80	dB
Supply Voltage Rejection Ratio		80	80	80	80	dB

Note 1: The maximum junction temperature of the LM216 and LM216A is 100°C, while that of the LM316 and LM316A is 70°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

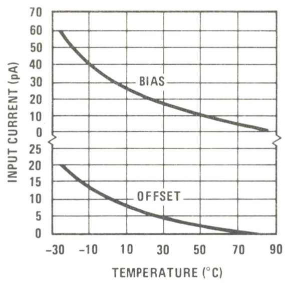
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

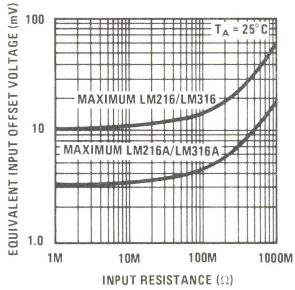
Note 4: These specifications apply for $±5V \leq V_S \leq ±20V$ and $-25°C \leq T_A \leq 85°C$, unless otherwise specified. With the LM316 and LM316A however, all temperature specifications are limited to $0°C \leq T_A \leq 55°C$.

typical performance characteristics

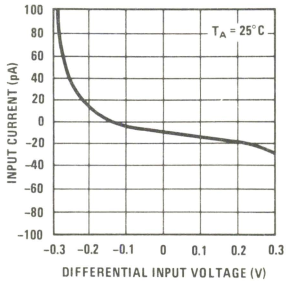
Input Currents



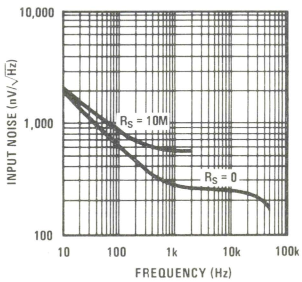
Offset Error



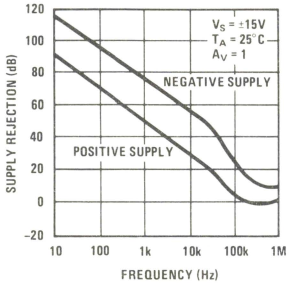
Input Current



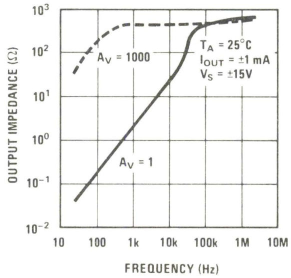
Input Noise Voltage



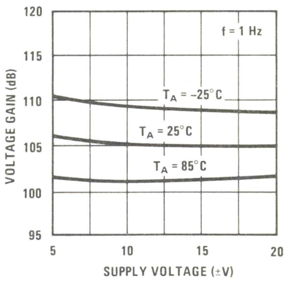
Power Supply Rejection



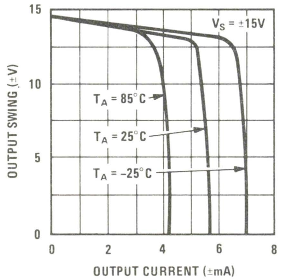
Closed Loop Output Impedance



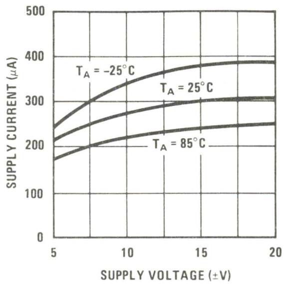
Voltage Gain



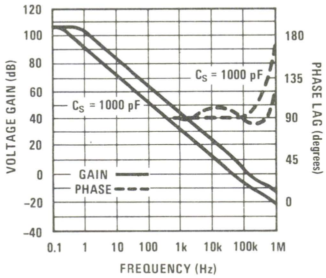
Output Swing



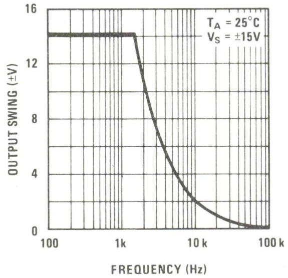
Supply Current



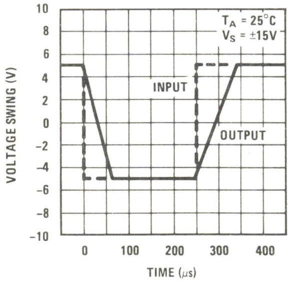
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM118/LM218 operational amplifier

general description

The LM118 and LM218 are precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate. They feature a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

features

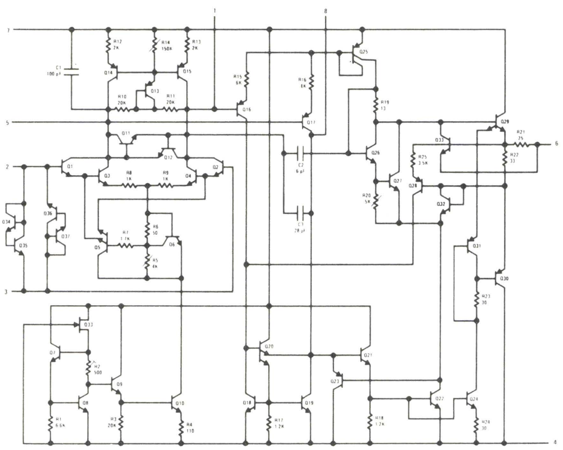
- 15 MHz small signal bandwidth
- Guaranteed 50V/μs slew rate
- Maximum bias current of 250 nA
- Operates from supplies of ±5V to ±20V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

The LM118 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency com pensation may be added for optimum performance For inverting applications, feedforward compen sation will boost the slew rate to over 150V/μs and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μs.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

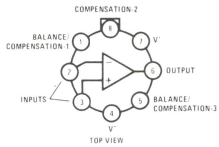
The LM218 is identical to the LM118 except that the LM218 has its performance specified over a −25°C to 85°C temperature range, instead of −55°C to 125°C.

schematic and connection diagrams



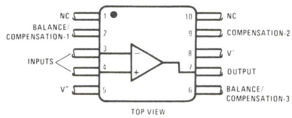
*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

Metal Can Package



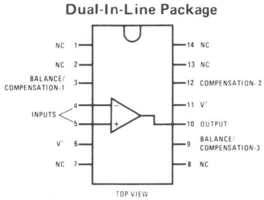
Order Number LM118H or LM218H
See Package 11

Flat Package



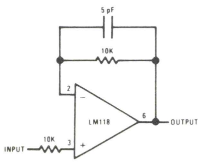
Order Number LM118F or LM218F
See Package 3

Dual-In-Line Package

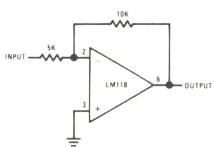


Order Number LM118D or LM218D
See Package 1

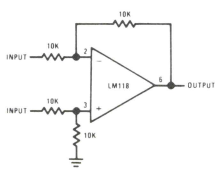
typical applications



Fast Voltage Follower



Fast Summing Amplifier



Differential Amplifier

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range LM118	−55°C to 125°C
LM218	−25°C to 85°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		2	4	mV
Input Offset Current	$T_A = 25°C$		6	50	nA
Input Bias Current	$T_A = 25°C$		120	250	nA
Input Resistance	$T_A = 25°C$	1	3		MΩ
Supply Current	$T_A = 25°C$		5	8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2$ kΩ	50	200		V/mV
Slew Rate	$T_A = 25°C$, $V_S = \pm 15V$, $A_V = 1$	50	70		V/µs
Small Signal Bandwidth	$T_A = 25°C$, $V_S = \pm 15V$		15		MHz
Input Offset Voltage				6	mV
Input Offset Current				100	nA
Input Bias Current				500	nA
Supply Current	$T_A = +125°C$		4.5	7	mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2$ kΩ	25			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 2$ kΩ	±12	±13		V
Input Voltage Range	$V_S = \pm 15V$	±11.5			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		70	80		dB

Note 1: The maximum junction temperature of the LM118 is 150°C, while that of the LM218 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

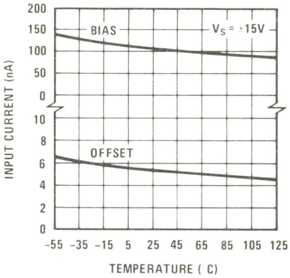
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

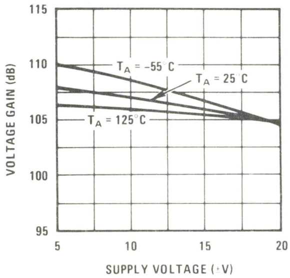
Note 4: These specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM218, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$. Also, power supplies must be bypassed with 0.1 µF disc capacitors.

typical performance characteristics

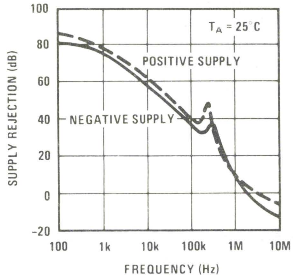
Input Current



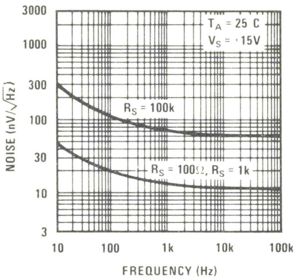
Voltage Gain



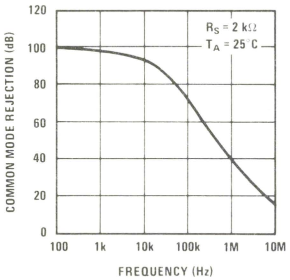
Power Supply Rejection



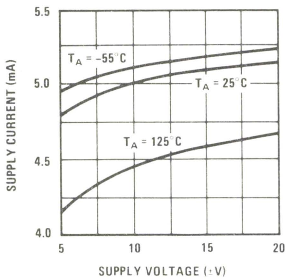
Input Noise Voltage



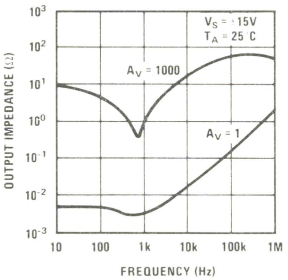
Common Mode Rejection



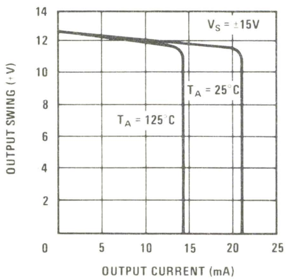
Supply Current



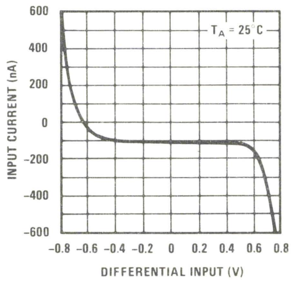
Closed Loop Output Impedance



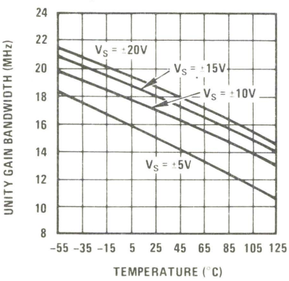
Current Limiting



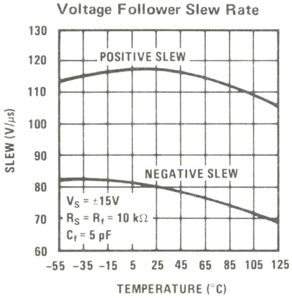
Input Current



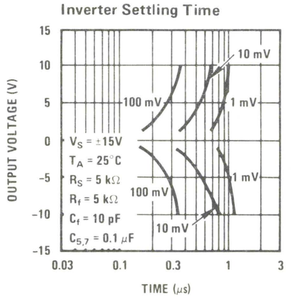
Unity Gain Bandwidth



Voltage Follower Slew Rate

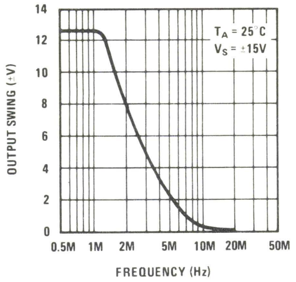


Inverter Settling Time

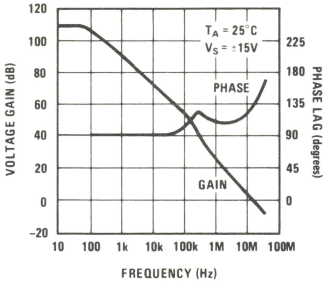


typical performance characteristics (con't)

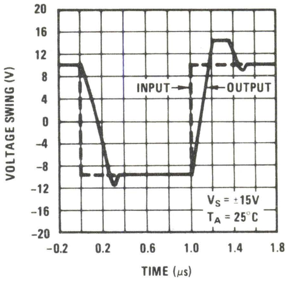
Large Signal Frequency Response



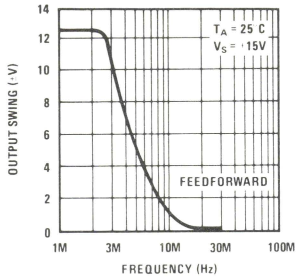
Open Loop Frequency Response



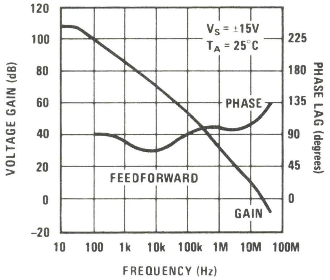
Voltage Follower Pulse Response



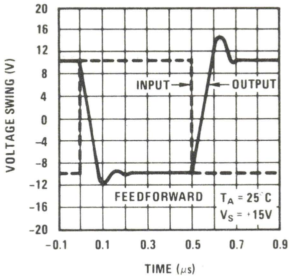
Large Signal Frequency Response



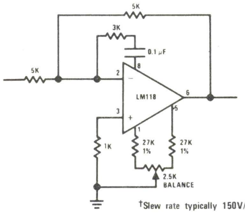
Open Loop Frequency Response



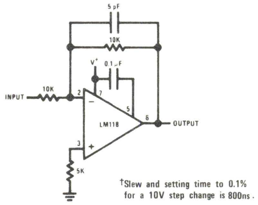
Inverter Pulse Response



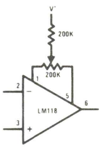
auxiliary circuits



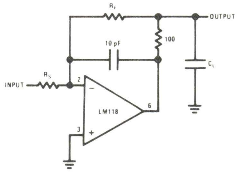
Feedforward Compensation for Greater Inverting Slew Rate†



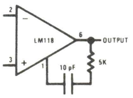
Compensation for Minimum Settling† Time



Offset Balancing

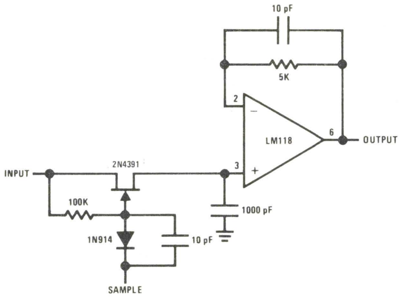


Isolating Large Capacitive Loads

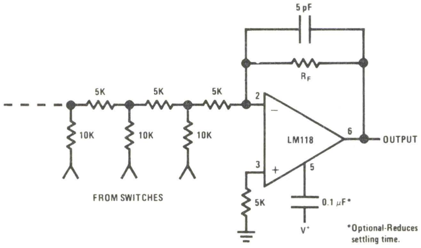


Overcompensation

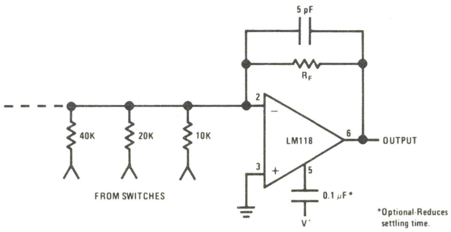
typical applications (con't)



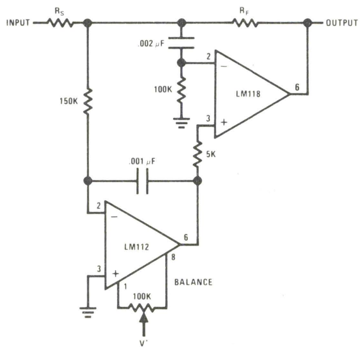
Fast Sample and Hold



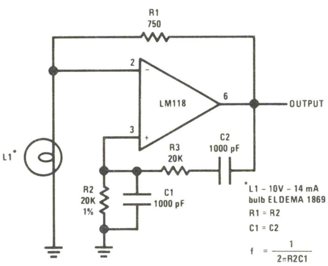
D/A Converter Using Ladder Network



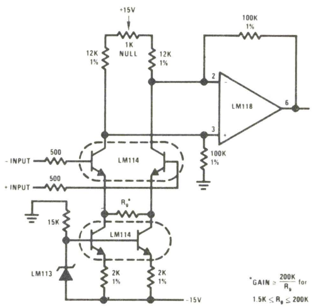
D/A Converter Using Binary Weighted Network



Fast Summing Amplifier
with Low Input Current



Wein Bridge Sine Wave Oscillator



Instrumentation Amplifier

Operational Amplifiers

LM318 operational amplifier

general description

The LM318 is a precision high speed operational amplifier designed for applications requiring wide bandwidth and high slew rate. It features a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

features

- 15 MHz small signal bandwidth
- Guaranteed 50V/μs slew rate
- Maximum bias current of 500 nA
- Operates from supplies of ±5V to ±20V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

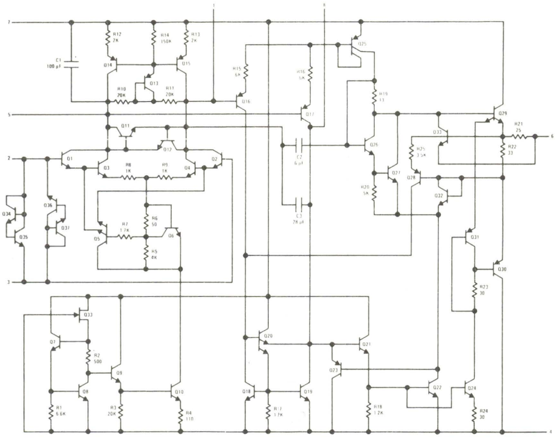
The LM318 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/μs and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μs.

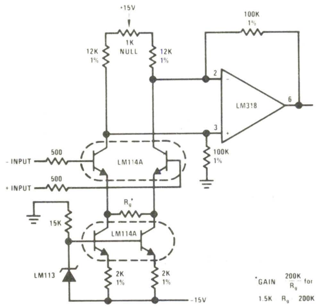
The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

The LM318 is specified for operation over 0°C to 70°C.

2

schematic diagram and typical application

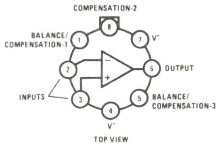




Instrumentation Amplifier

connection diagrams

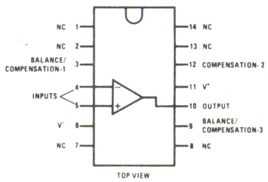
Metal Can Package*



***Pin connections shown on schematic diagram and typical applications are for TO-5 package.**

Order Number LM318H
See Package 11

Dual-In-Line Package



Order Number LM318D
See Package 1

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		4	10	mV
Input Offset Current	$T_A = 25°C$		30	200	nA
Input Bias Current	$T_A = 25°C$		150	500	nA
Input Resistance	$T_A = 25°C$	0.5	3		MΩ
Supply Current	$T_A = 25°C$		5	10	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geq 2\ k\Omega$	25	200		V/mV
Slew Rate	$T_A = 25°C$, $V_S = \pm15V$, $A_V = 1$	50	70		V/µs
Small Signal Bandwidth	$T_A = 25°C$, $V_S = \pm15V$		15		MHz
Input Offset Voltage				15	mV
Input Offset Current				300	nA
Input Bias Current				750	nA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geq 2\ k\Omega$	20			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 2\ k\Omega$	±12	±13		V
Input Voltage Range	$V_S = \pm15V$	±11.5			V
Common Mode Rejection Ratio		70	100		dB
Supply Voltage Rejection Ratio		65	80		dB

Note 1: The maximum junction temperature of the LM318 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

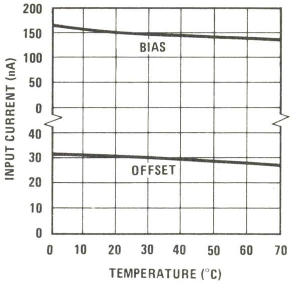
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

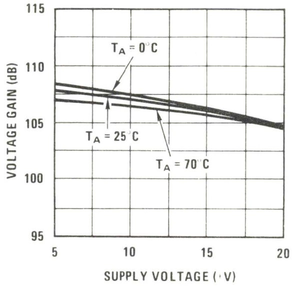
Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified. For proper operation, the power supplies must be bypassed with 0.1 µF disc capacitors.

typical performance characteristics

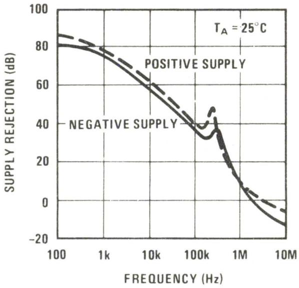
Input Current



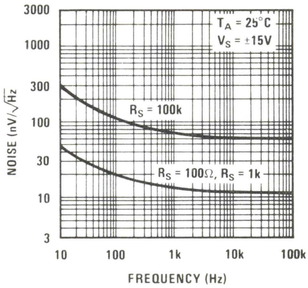
Voltage Gain



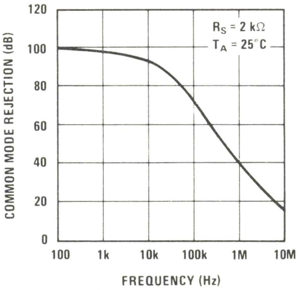
Power Supply Rejection



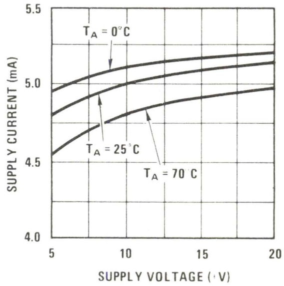
Input Noise Voltage



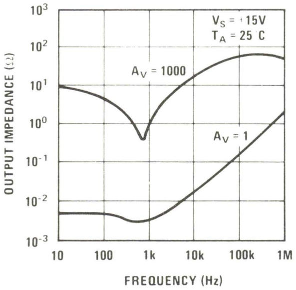
Common Mode Rejection



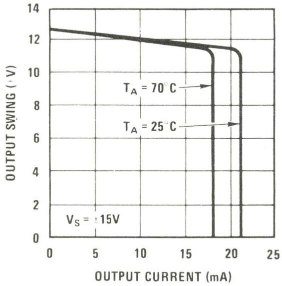
Supply Current



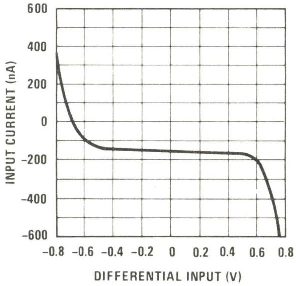
Closed Loop Output Impedance



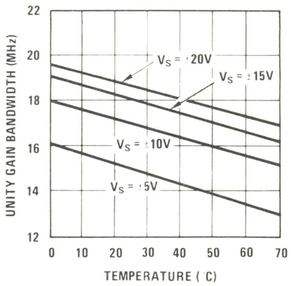
Current Limiting



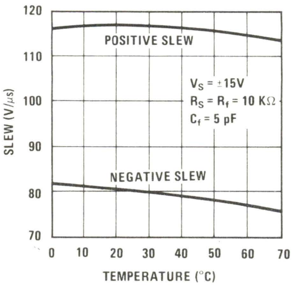
Input Current



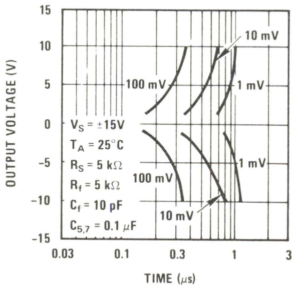
Unit Gain Bandwidth



Voltage Follower Slew Rate

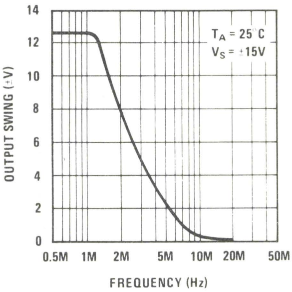


Inverter Settling Time

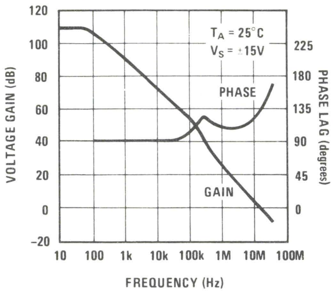


typical performance characteristics (con't)

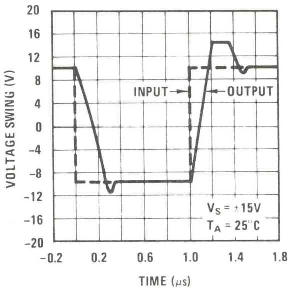
Large Signal Frequency Response



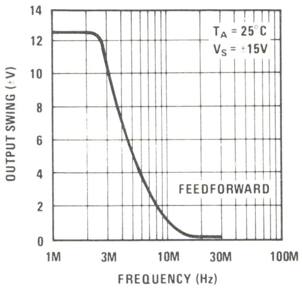
Open Loop Frequency Response



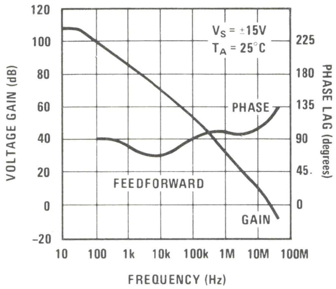
Voltage Follower Pulse Response



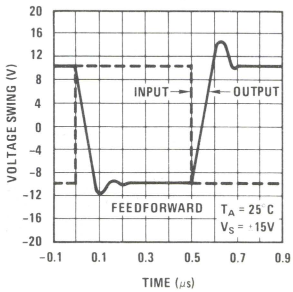
Large Signal Frequency Response



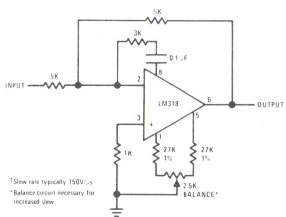
Open Loop Frequency Response



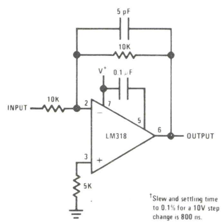
Inverter Pulse Response



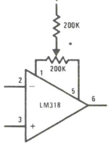
auxiliary circuits



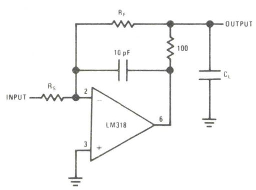
Feedforward Compensation for Greater Inverting Slew Rate†



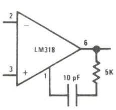
Compensation for Minimum Settling† Time



Offset Balancing

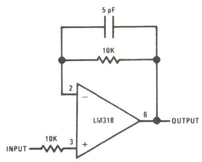


Isolating Large Capacitive Loads

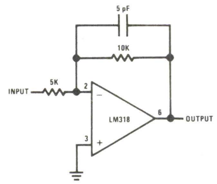


Overcompensation

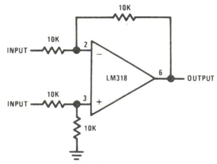
typical applications (con't)



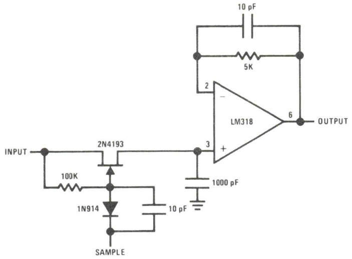
Fast Voltage Follower



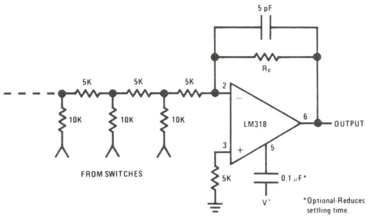
Fast Summing Amplifier



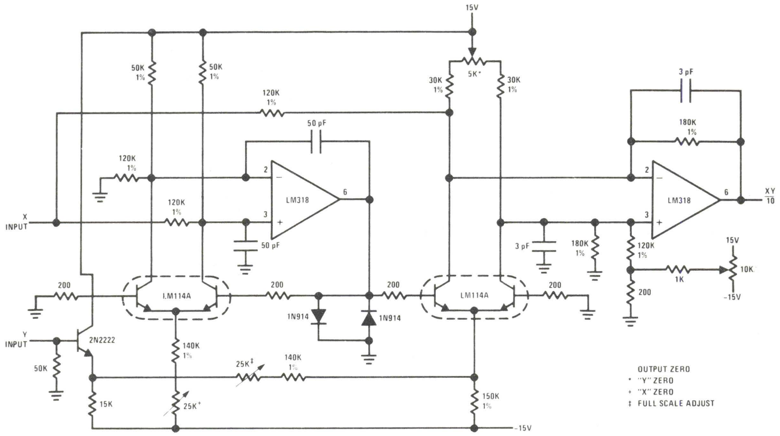
Differential Amplifier



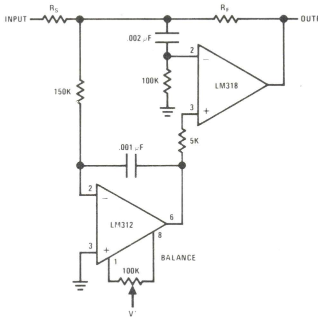
Fast Sample and Hold



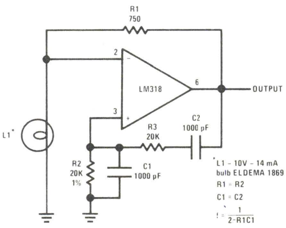
D/A Converter Using Ladder Network



Four Quadrant Multiplier



Fast Summing Amplifer with Low Input Current



Wein Bridge Sine Wave Oscillator

Operational Amplifiers

LM121/LM221/LM321 precision preamplifier

general description

The LM121 series are precision preamplifiers designed to operate with general purpose operational amplifiers to drastically decrease DC errors. Drift, bias current, common mode and supply rejection are more than a factor of 10 better than standard op amps alone. Further, the added DC gain of the LM121 decreases the closed loop gain error.

The LM121 operates with supply voltages from ±3V to ±20V and has sufficient supply rejection to operate from unregulated supplies. The operating current is programmable from 5μA to 200μA so bias current, offset current, gain and noise can be optimized for the particular application while still realizing very low drift. Super-gain transistors are used for the input stage so input error currents are lower than conventional amplifiers at the same operating current. Further, the initial offset voltage is easily nulled to zero.

advantages

- Permits optimization of general purpose op amps
- Replaces many specialized op amps

features

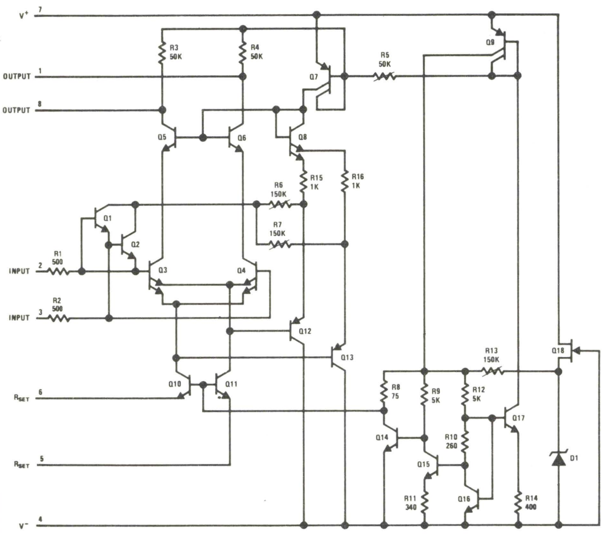
- Guaranteed drift less than 1μV/°C when nulled
- Offset voltage less than 0.7 mV
- Bias current less than 10 nA at 10μA operating current
- CMRR 120 dB minimum
- 114 dB supply rejection
- Easily nulled offset voltage

The extremely low drift of the LM121 will improve accuracy on almost any precision DC circuit. For example, instrumentation amplifier, strain gauge amplifiers and thermocouple amplifiers now using chopper amplifiers can be made with the LM121. The full differential input and high common mode rejection are another advantage over choppers. For applications where low bias current is more important than drift, the operating current can be reduced to low values. High operating currents can be used for low voltage noise with low source resistance. The programmable operating current of the LM121 allows tailoring the input characteristics to match those of specialized op amps.

The LM121 is specified over a −55°C to 125°C temperature range, the LM221 over a −25°C to 85°C range and the LM321 over a 0°C to 70°C temperature range.

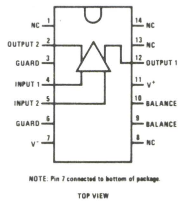
A lower drift version of the LM121 — the LM121A series — is available for applications requiring 0.2μV/°C offset voltage drift.

schematic and connection diagrams



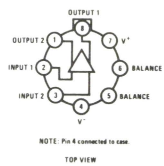
*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

Dual-In-Line Package



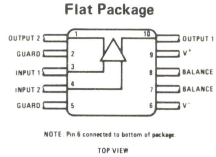
Order Number LM121D, LM221D or LM321D
See Package 1

Metal Can Package



Order Number LM121H, LM221H or LM321H
See Package 11

Flat Package



Order Number LM121F, LM221F or LM321F
See Package 3

Note: Outputs are inverting from the input of the same number.

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500mW
Differential Input Voltage (Notes 2, 3)	±15V
Input Voltage (Note 3)	±15V
Operating Temperature Range	
LM121	−55°C to 125°C
LM221	−25°C to 85°C
LM321	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	LM121 LM221	LM321	UNITS	
Input Offset Voltage	$T_A = 25°C$ $6.4k \leq R_{Set} \leq 70k$	0.7	1.5	mV	Max
Input Offset Current	$T_A = 25°C$ $R_{Set} = 70k$	1	2	nA	Max
	$R_{Set} = 6.4k$	10	20	nA	Max
Input Bias Current	$T_A = 25°C$ $R_{Set} = 70k$	10	18	nA	Max
	$R_{Set} = 6.4k$	100	180	nA	Max
Input Resistance	$T_A = 25°C$ $R_{Set} = 70k$	4	2	MΩ	Min
	$R_{Set} = 6.4k$	0.4	0.2	MΩ	Min
Supply Current	$T_A = 25°C$	1.5	2.2	mA	Max
Input Offset Voltage	$6.4k \leq R_{Set} = 70k$	1	2.5	mV	Max
Input Bias Current	$R_{Set} = 70k$	30	28	nA	Max
	$R_{Set} = 6.4k$	300	280	nA	Max
Input Offset Current	$R_{Set} = 70k$	3	4	nA	Max
	$R_{Set} = 6.4k$	30	40	nA	Max
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 200\Omega$ $6.4k \leq R_{Set} \leq 70k$ Offset Voltage Nulled	1	1	μV/°C	Max
Supply Current		2.5	3.5	mA	Max
Input Voltage Range	$V_S = \pm15V$ $R_{Set} = 70k$	±13	±13	V	Min
	$R_{Set} = 6.4k$ (Note 5)	+7 −13	+7 −13	V	Min
Common Mode Rejection Ratio	$R_{Set} = 70k$	120	114	dB	Min
	$R_{Set} = 6.4k$	114	114	dB	Min
Supply Voltage Rejection Ratio	$R_{Set} = 70k$	120	114	dB	Min
	$R_{Set} = 6.4k$	114	114	dB	Min
Voltage Gain	$T_A = 25°C$ $R_{Set} = 70k$ $R_L > 3$ meg	16	12	V/V	Min

Note 1: The maximum junction temperature of the LM121 is 150°C, while that of the LM221 is 100°C. The maximum junction temperature of the LM321 is 85°C. For operating at elevated temperature, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/6-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce cooper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes in series with a 500Ω resistor for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm5 \leq V_S < \pm20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM221, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$, and for the LM321 the specifications apply over a 0°C to 70°C temperature range.

Note 5: External precision resistors—0.1%—can be placed from pins 1 and 8 to 7 to increase positive common mode range.

2

typical applications

Low Drift Op Amp Using the LM121 as a Preamp

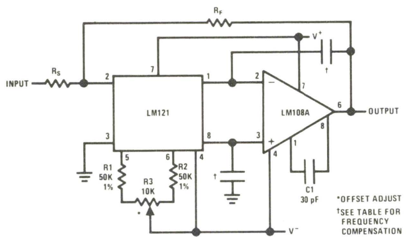


FIGURE 1.

Gain of 1000 Instrumentation Amplifier‡

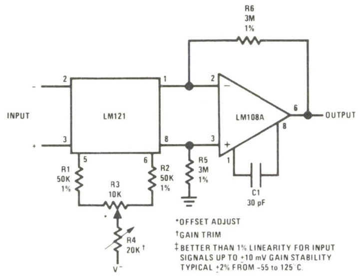


FIGURE 2.

frequency compensation

Universal Frequency Compensation

The additional gain of the LM121 preamplifier when used with an operational amplifier usually necessitates additional frequency compensation. When the closed loop gain of the op amp with the LM121 is less than the gain of the LM121 alone, more compensation is needed. The worst case situation is when there is 100% feedback – such as a voltage follower or integrator – and the gain of the LM121 is high. When high closed loop gains are used – for example $A_V = 1000$ – and only an addition gain of 200 is inserted by the LM121, the frequency compensation of the op amp will usually suffice.

The frequency compensation shown here is designed to operate with any unity-gain stable op amp. Figure 1 shows the basic configuration of frequency stabilizing network. In operation the output of the LM121 is rendered single ended by a 0.01μF bypass capacitor to ground. Overall frequency compensation then is achieved by an integrating capacitor around the op amp.

$$\text{Bandwidth at unity gain} \cong \frac{12}{2\pi R_{Set} C}$$

$$\text{for 0.5 MHz bandwidth } C = \frac{4}{10^6 R_{Set}}$$

For use with higher frequency op amps such as the LM118 the bandwidth may be increased to about 2 MHz.

If the closed loop gain is greater than unity "C" may be decreased by

$$C = \frac{4}{10^6 A_{CL} R_{Set}}$$

Alternate Compensation

The two compensation capacitors can be made equal for improved power supply rejection. In this case the formula for the compensation capacitor is

$$C = \frac{8}{10^6 A_{CL} R_{Set}}$$

Table 1 shows typical values for the two compensating capacitors for various gains and operating currents.

TABLE 1.

CLOSED LOOP GAIN	CURRENT SET RESISTOR				
	120kΩ	60kΩ	30kΩ	12kΩ	6kΩ
$A_V = 1$	68	130	270	680	1300
$A_V = 5$	15	27	56	130	270
$A_V = 10$	10	15	27	68	130
$A_V = 50$	1	3	5	15	27
$A_V = 100$	–	1	3	5	10
$A_V = 500$	–	–	1	1	3
$A_V = 1000$	–	–	–	–	–

This table applies for the LM108, LM101A, LM741, LM118. Capacitance is in pF.

Design equations for the LM121 series:

$$\text{Gain } A_V \approx \frac{1.2 \times 10^6}{R_{Set}}$$

Null Pot Value should be 10% of R_{Set}

$$\text{Operating Current} \approx \frac{2 \times 0.65V}{R_{Set}}$$

$$\text{Positive Common Mode Limit} \approx V^+ - 0.6 + \frac{0.65V \times 50k}{R_{Set}}$$

Operational Amplifiers

LM124/LM224/LM324 quad op amps

general description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard $+5V_{DC}$ power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional $\pm 15\ V_{DC}$ power supplies.

unique characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

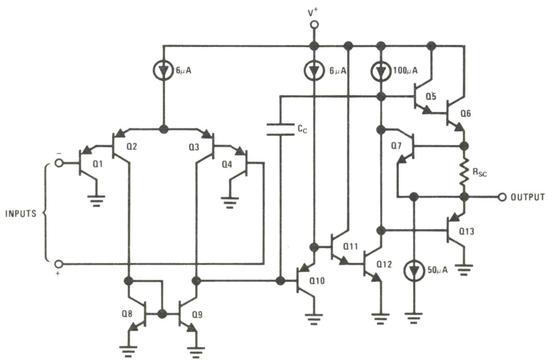
advantages

- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

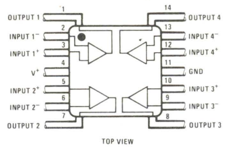
features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  - Single supply $3V_{DC}$ to $30V_{DC}$
  - or dual supplies $\pm 1.5V_{DC}$ to $\pm 15V_{DC}$
- Very low supply current drain (800μA) – essentially independent of supply voltage (1 mW/op amp at $+5V_{DC}$)
- Low input biasing current $45\ nA_{DC}$ (temperature compensated)
- Low input offset voltage $2\ mV_{DC}$ and offset current $5\ nA_{DC}$
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing $0V_{DC}$ to $V^+ - 1.5V_{DC}$

schematic and connection diagrams

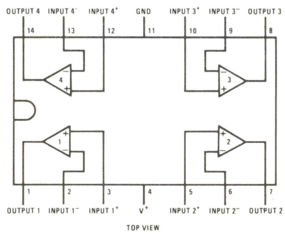


Flat Package



Order Number LM124F
See Package 4

Dual-In-Line Package



Order Number LM124D, LM224D, LM324D, or LM324N
See Package 1 or 22

absolute maximum ratings

Supply Voltage, V^+	$32\ V_{DC}$ or $\pm16\ V_{DC}$
Differential Input Voltage	$32\ V_{DC}$
Input Voltage	$-0.3\ V_{DC}$ to $+32\ V_{DC}$
Power Dissipation (Note 1)	
Molded DIP (LM324N)	570 mW
Cavity DIP (LM124D, LM224D & LM324D)	900 mW
Flat Pack (LM124F)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
$V^+ \leq 15\ V_{DC}$ and $T_A = 25^\circ C$	
Operating Temperature Range	
LM324	0°C to +70°C
LM224	−25°C to +85°C
LM124	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V^+ = +5\ V_{DC}$ and $T_A = 25^\circ C$ unless otherwise noted)

PARAMETER	CONDITIONS	LM124			LM224, LM324			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 0\Omega$		2	5		2	7	mV_{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$		45	300		45	500	nA_{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		±3	±30		±5	±50	nA_{DC}
Input Common-Mode Voltage Range (Note 4)		0		$V^+-1.5$	0		$V^+-1.5$	V_{DC}
Supply Current	$R_L = \infty$ On All Op Amps		0.8	2		0.8	2	mA_{DC}
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$		100			100		V/mV
Output Voltage Swing	$R_L = 2\ k\Omega$	0		$V^+-1.5$	0		$V^+-1.5$	V_{DC}
Common Mode Rejection Ratio	DC		85			85		dB
Power Supply Rejection Ratio	DC		100			100		dB
Amplifier-to-Amplifier Coupling	f = 1 kHz to 20 kHz (Input Referred)		−120			−120		dB
Output Current Source	$V_{IN}^+ = +1\ V_{DC}$, $V_{IN}^- = 0\ V_{DC}$	20	40		20	40		mA_{DC}
Output Current Sink	$V_{IN}^- = +1\ V_{DC}$, $V_{IN}^+ = 0\ V_{DC}$	10	20		10	20		mA_{DC}

Note 1: For operating at high temperatures, the LM324 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224 and LM124 can be derated based on a +150°C maximum junction temperature.

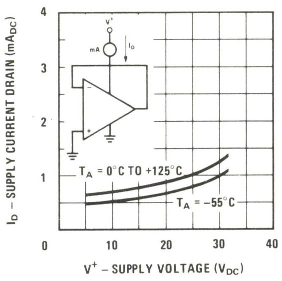
Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of $+15V_{DC}$, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.

Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

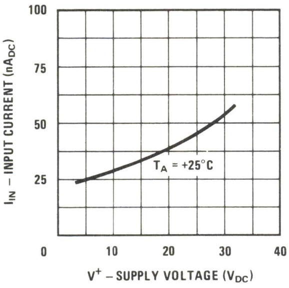
Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V^+ - 1.5V$, but either or both inputs can go to $+30V_{DC}$ without damage.

typical performance characteristics

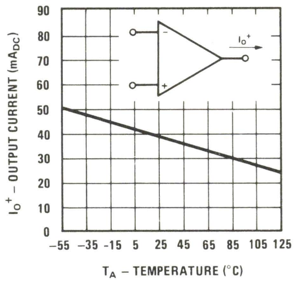
Supply Current



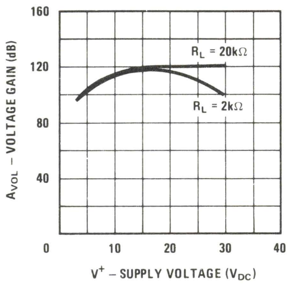
Input Current



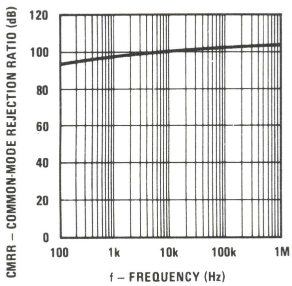
Current Limiting



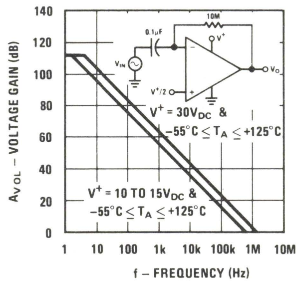
Voltage Gain



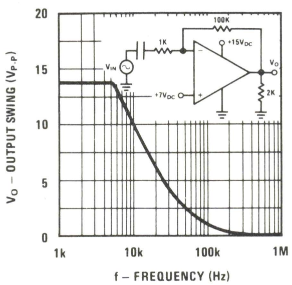
Common-Mode Rejection Ratio



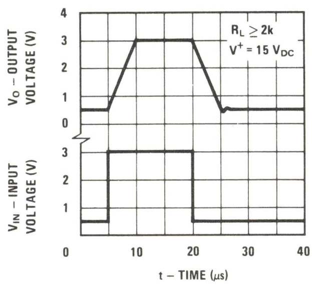
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



application hints

The LM124 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of $0V_{DC}$. These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At 25°C amplifier operation is possible down to a minimum supply voltage of $2.3V_{DC}$.

The pinouts of the package have been designed to simplify PC board layouts. Inverting inputs are adjacent to outputs for all of the amplifiers and the outputs have also been placed at the corners of the package (pins 1, 7, 8, and 14).

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3V_{DC}$ (at 25°C). An input clamp consisting of a diode-connected NPN transistor (C-B short) can be used.

To reduce the power supply current drain, the amplifiers have a class A output stage for small signal levels which converts to class B in a large signal mode. This allows the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

For AC applications, where the load is capacitively coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the class A bias current and prevent crossover distortion. Where the load is directly coupled, as in DC applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50 pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

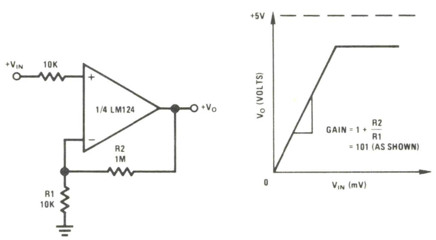
The bias network of the LM124 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from $3V_{DC}$ to $30V_{DC}$.

Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers. The larger value of output source current which is available at 25°C provides a larger output current capability at elevated temperatures (see typical performance characteristics) than a standard IC op amp.

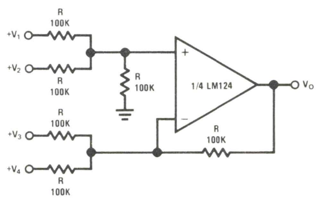
The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of $V^+/2$) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

typical single-supply applications ($V^+ = 5V_{DC}$)

Non-Inverting DC Gain (0V Input = 0V Output)



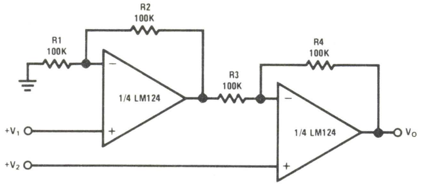
DC Summing Amplifier
($V_{IN'S} \geq 0V_{DC}$ AND $V_O \geq 0V_{DC}$)



WHERE $V_O = V_1 + V_2 - V_3 - V_4$
$(V_1 + V_2) \geq (V_3 + V_4)$ TO KEEP $V_O > 0V_{DC}$

typical single-supply applications (con't) ($V^+ = 5V_{DC}$)

High Input Z, DC Differential Amplifier

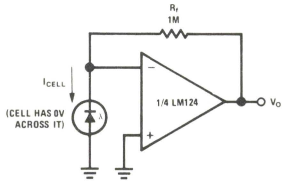


FOR $\frac{R1}{R2} = \frac{R4}{R3}$ (CMRR DEPENDS ON THIS RESISTOR RATIO MATCH)

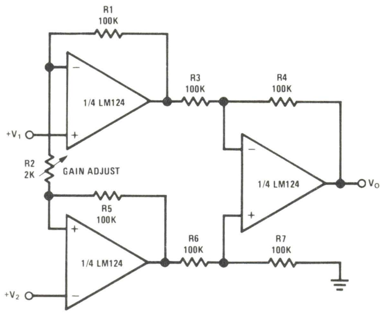
$$V_O = \left(1 + \frac{R4}{R3}\right)(V_2 - V_1)$$

AS SHOWN: $V_O = 2(V_2 - V_1)$

Photo Voltaic-Cell Amplifier



High Input Z Adjustable-Gain DC Instrumentation Amplifier

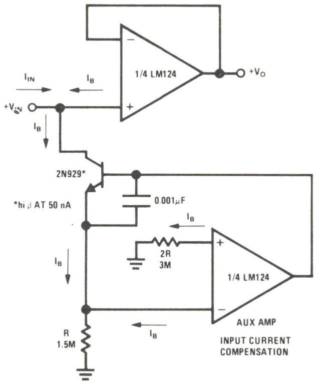


IF R1 = R5 & R3 = R4 = R6 = R7 (CMRR DEPENDS ON MATCH)

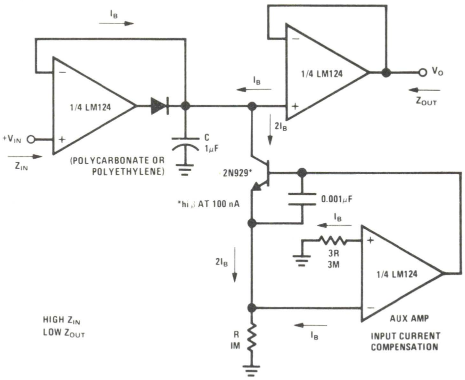
$$V_O = 1 + \frac{2\,R1}{R2}\,(V_2 - V_1)$$

AS SHOWN $V_O = 101\,(V_2 - V_1)$

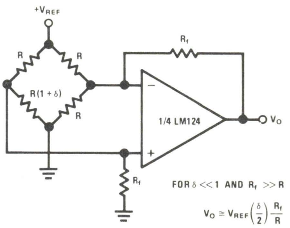
Using Symmetrical Amplifiers to Reduce Input Current (General Concept)



Low Drift Peak Detector



Bridge Current Amplifier

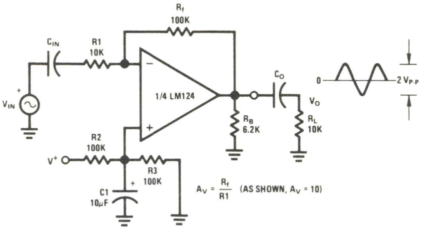


FOR $\delta << 1$ AND $R_f >> R$

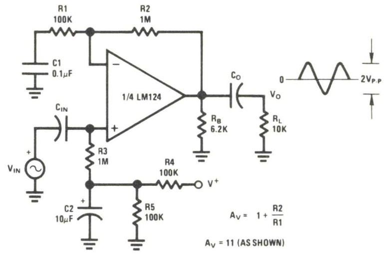
$$V_O \cong V_{REF}\left(\frac{\delta}{2}\right)\frac{R_f}{R}$$

typical single-supply applications (con't) ($V^+ = 5V_{DC}$)

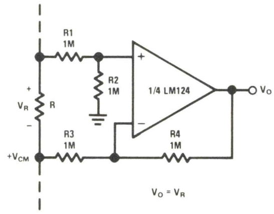
AC Coupled Inverting Amplifier



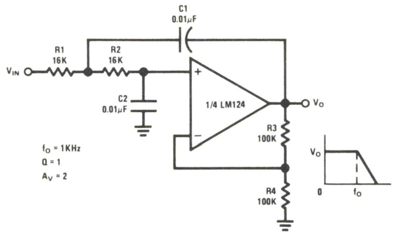
AC Coupled Non-Inverting Amplifier



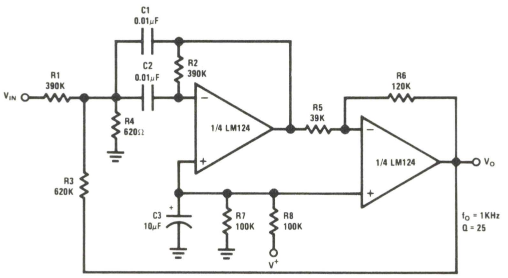
Ground Referencing A Differential Input Signal



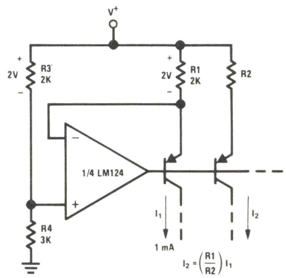
DC Coupled Low-Pass RC Active Filter



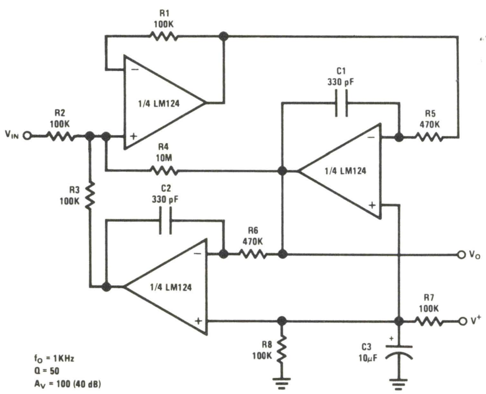
Bandpass Active Filter



Fixed Current Sources

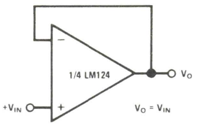


"BI-QUAD" RC Active Bandpass Filter

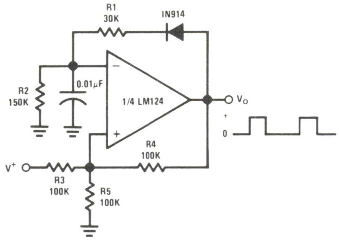


typical single-supply applications (con't) ($V^+ = 5V_{DC}$)

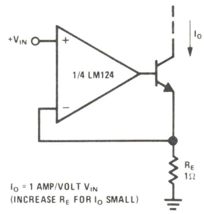
Voltage Follower



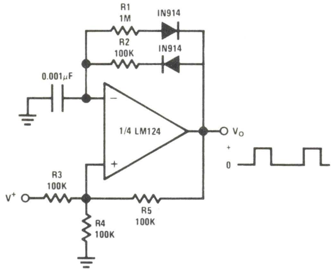
Pulse Generator



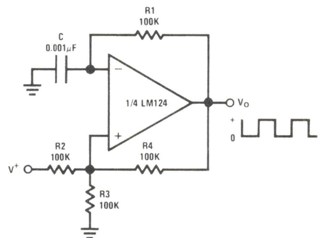
High Compliance Current Sink



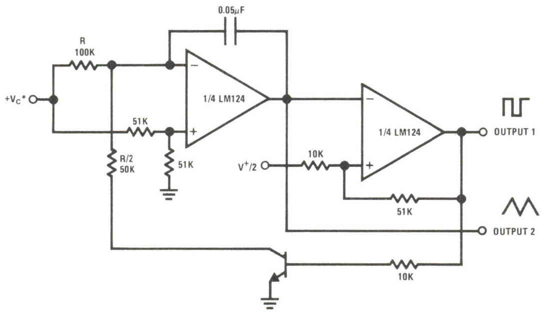
Pulse Generator



Squarewave Oscillator

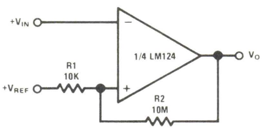


Voltage Controlled Oscillator (VCO)

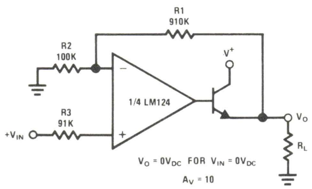


*WIDE CONTROL VOLTAGE RANGE: $0V_{DC} \leq V_C \leq 2(V^+ - 1.5 V_{DC})$

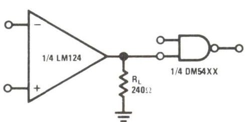
Comparator With Hysteresis



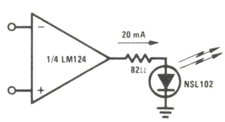
Power Amplifier



Driving TTL



LED Driver



Operational Amplifiers

LM709 operational amplifier

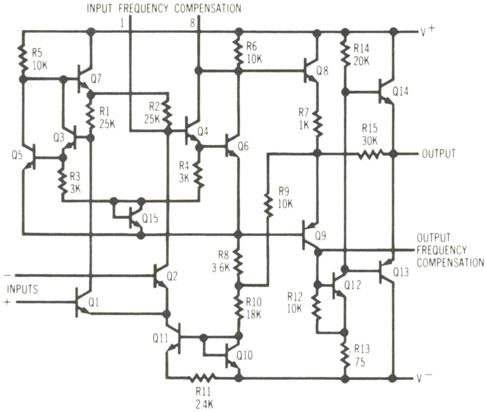
general description

The LM709 is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

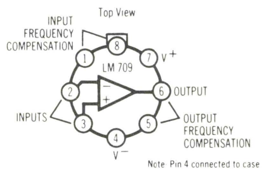
External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The fact that the amplifier is built on a single silicon chip provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

schematic and connection diagrams



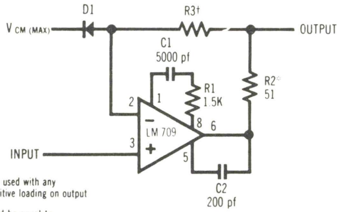
Metal Can



Order Number LM709H
See Package 11

typical applications*

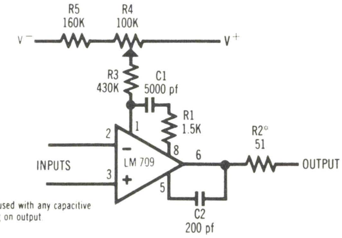
Voltage Follower



*To be used with any capacitive loading on output

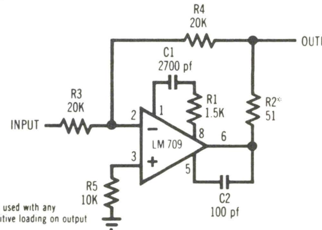
†Should be equal to dc source resistance on input.

Offset Balancing Circuit



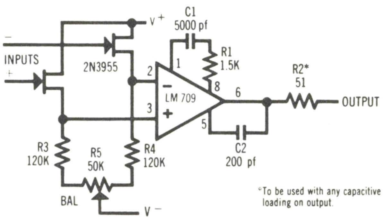
*To be used with any capacitive loading on output

Unity Gain Inverting Amplifier



*To be used with any capacitive loading on output

FET Operational Amplifier



*To be used with any capacitive loading on output.

* Pin connections shown are for Metal Can package.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	300 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration ($T_A = 25°C$)	5 sec
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		1.0	5.0	mV
Input Bias Current	$T_A = 25°C$		200	500	nA
Input Offset Current	$T_A = 25°C$		50	200	nA
Input Resistance	$T_A = 25°C$	150	400		kΩ
Output Resistance	$T_A = 25°C$		150		Ω
Supply Current	$T_A = 25°C$, $V_S = \pm15V$		2.6	5.5	mA
Transient Response	$V_{IN} = 20\ mV$, $C_L \leq 100\ pF$				
Risetime	$T_A = 25°C$		0.3	1.0	µS
Overshoot			10	30	%
Slewing Rate	$T_A = 25°C$		0.25		V/µS
Input Offset Voltage	$R_S \leq 10\ k\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\ \Omega$		3.0		µV/°C
	$R_S = 10\ k\Omega$		6.0		µV/°C
Large-Signal Voltage Gain	$V_S = \pm15V$, $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm10V$	25,000	45,000	70,000	
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±12	±14		V
	$V_S = \pm15V$, $R_L = 2\ k\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm15V$	±8.0	±10		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	90		db
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$		25	150	µV/V
Input Offset Current	$T_A = +125°C$		20	200	nA
	$T_A = -55°C$		100	500	nA
Input Bias Current	$T_A = -55°C$		0.5	1.5	µA
Input Resistance	$T_A = -55°C$	40	100		kΩ

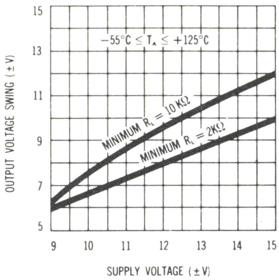
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).

Note 2: These specifications apply for $-55°C \leq T_A \leq +125°C$, $\pm 9V \leq V_S \leq \pm15V$, $C_1 = 5000\ pF$, $R_1 = 1.5K$, $C_2 = 200\ pF$ and $R_2 = 51\Omega$ unless otherwise specified.

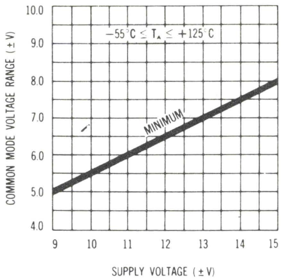
2

guaranteed performance characteristics

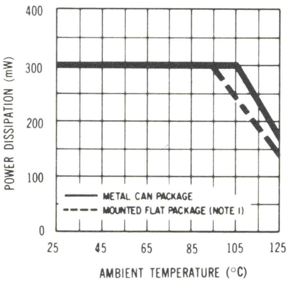
Output Voltage Swing



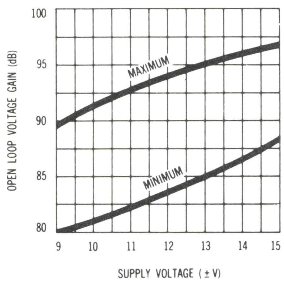
Input Common Mode Voltage Range



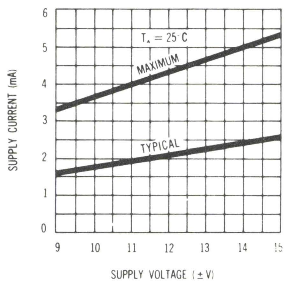
Maximum Power Dissipation



Voltage Gain

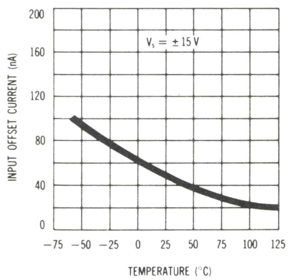


Supply Current

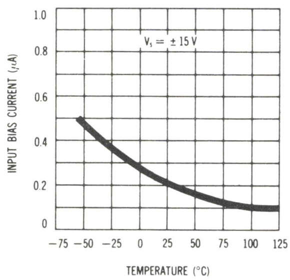


typical performance characteristics

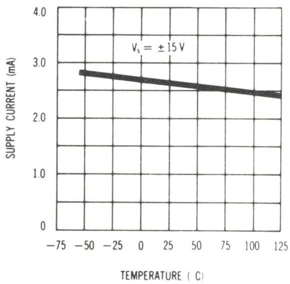
Input Offset Current



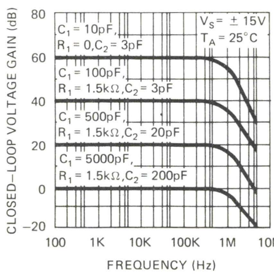
Input Bias Current



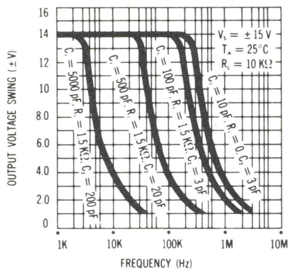
Supply Current



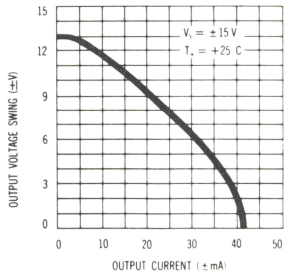
Frequency Responce For Various Closed-Loop Gains



Output Voltage Swing as a Function of Frequency



Output Voltage Swing



Operational Amplifiers

LM709A operational amplifier

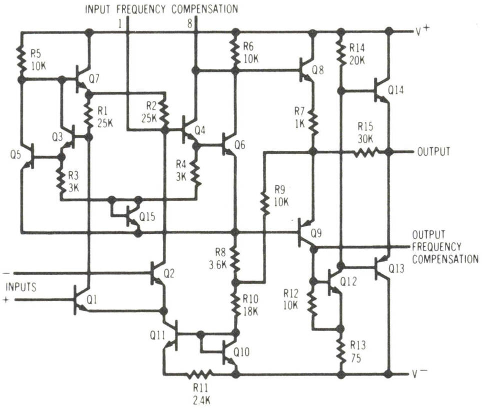
general description

The LM709A is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

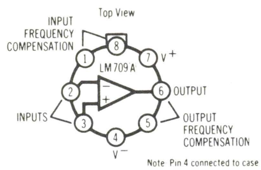
External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The fact that the amplifier is built on a single silicon chip provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

schematic and connection diagrams



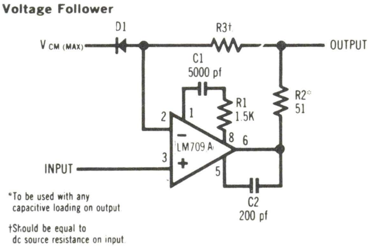
Metal Can



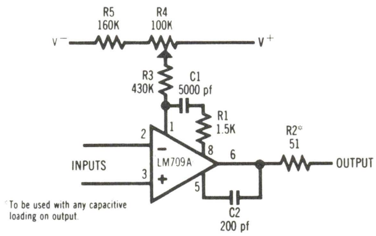
Order Number LM709AH
See Package 11

typical applications

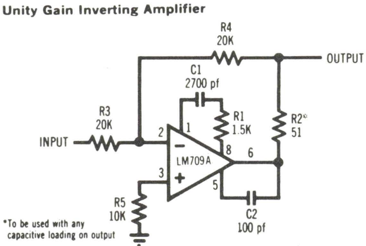
Voltage Follower



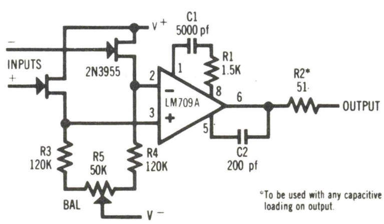
Offset Balancing Circuit



Unity Gain Inverting Amplifier



FET Operational Amplifier



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	300 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration ($T_A = 25°C$)	5 sec
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

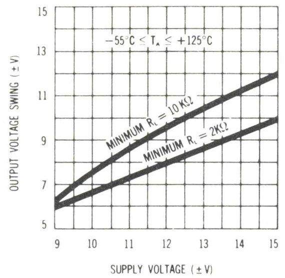
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		0.6	2.0	mV
Input Bias Current	$T_A = 25°C$		100	200	nA
Input Offset Current	$T_A = 25°C$		10	50	nA
Input Resistance	$T_A = 25°C$	350	700		kΩ
Output Resistance	$T_A = 25°C$		150		Ω
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		2.5	3.6	mA
Transient Response	$V_{IN} = 20\ mV$, $C_L \leq 100\ pF$				
Risetime	$T_A = 25°C$			1.5	μs
Overshoot				30	%
Slewing Rate	$T_A = 25°C$		0.25		V/μs
Input Offset Voltage	$R_S \leq 10\ k\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\Omega$, $T_A = 25°C$ to $+125°C$		1.8	10	μV/°C
	$R_S = 50\Omega$, $T_A = 25°C$ to $-55°C$		1.8	10	μV/°C
	$R_S = 10\ k\Omega$, $T_A = 25°C$ to $+125°C$		2.0	15	μV/°C
	$R_S = 10\ k\Omega$, $T_A = 25°C$ to $-55°C$		4.8	25	μV/°C
Large-Signal Voltage Gain	$V_S = \pm 15V$, $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10V$	25,000		70,000	
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±12	±14		V
	$V_S = \pm 15V$, $R_L = 2\ k\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm 15V$	±8.0			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	80	110		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$		40	100	μV/V
Input Offset Current	$T_A = +125°C$		3.5	5.0	nA
	$T_A = -55°C$		40	250	nA
Input Bias Current	$T_A = -55°C$		300	600	nA
Input Resistance	$T_A = -55°C$	85	170		kΩ

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package.

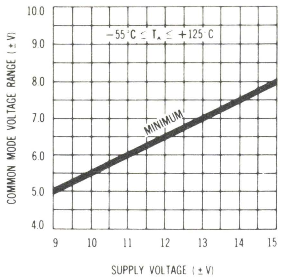
Note 2: These specifications apply for $-55°C \leq T_A \leq +125°C$, $\pm 9V \leq V_S \leq \pm 15V$, $C_1 = 5000\ pF$, $R_1 = 1.5K$, $C_2 = 200\ pF$ and $R_2 = 51\Omega$ unless otherwise specified.

guaranteed performance characteristics

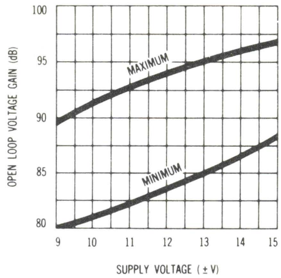
Output Voltage Swing



Input Common Mode Voltage Range

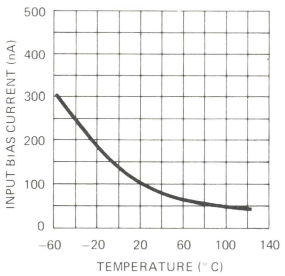


Voltage Gain

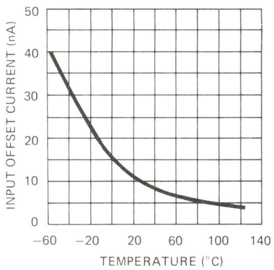


typical performance characteristics

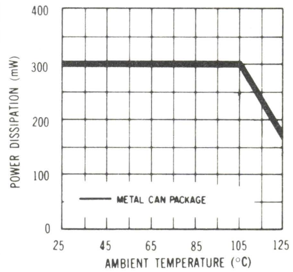
Input Bias Current as a Function of Ambient Temperature



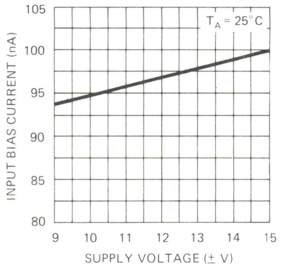
Input Offset Current as a Function of Ambient Temperature



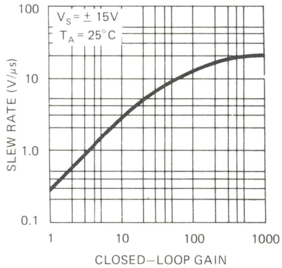
Maximum Power Dissipation



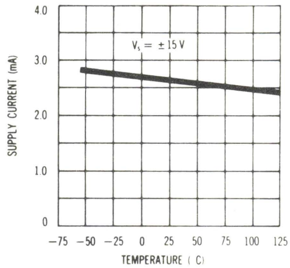
Input Bias Current as a Function of Supply Voltage



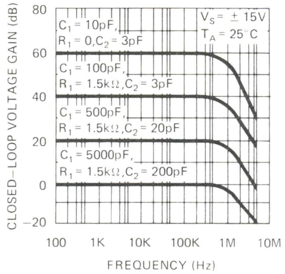
Slew Rate as a Function of Closed-Loop Gain Using Recommended Compensation Networks



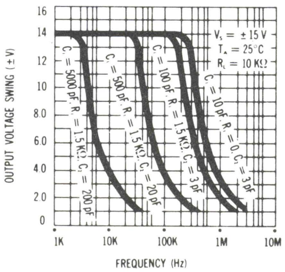
Supply Current



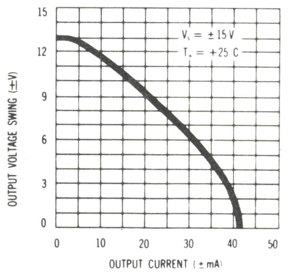
Frequency Responce For Various Closed -Loop Gains



Output Voltage Swing as a Function of Frequency



Output Voltage Swing



Operational Amplifiers

LM709C operational amplifier

general description

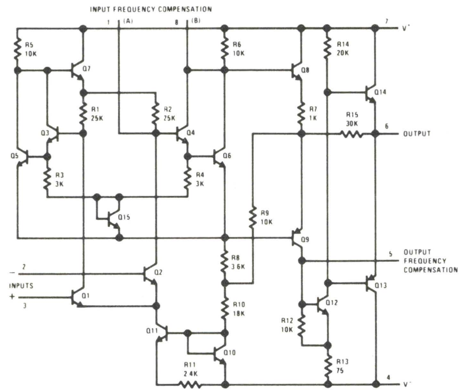
The LM709C is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

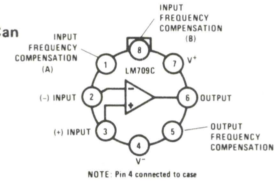
The fact that the amplifier is built on a single silicon ship provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

The LM709C is commercial-industrial version of the LM709. It is identical to the LM709 except that it is specified for operation from 0°C to 70°C.

schematic** and connection diagrams

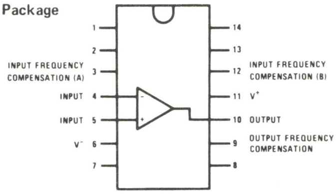


Metal Can



Order Number LM709CH
See Package 11

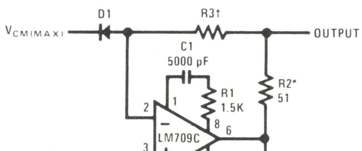
Dip Package



Order Number LM709CN
See Package 22

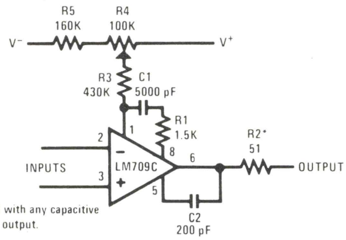
typical applications**

Voltage Follower



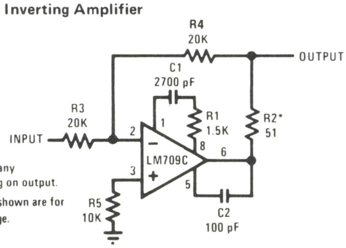
*To be used with any capacitive loading on output.
†Should be equal to dc source resistance on input.

Offset Balancing Circuit



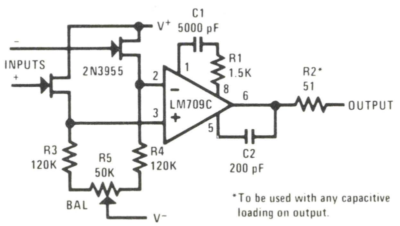
*To be used with any capacitive loading on output.

Unity Gain Inverting Amplifier



*To be used with any capacitive loading on output.
**Pin connections shown are for metal can package.

FET Operational Amplifier



*To be used with any capacitive loading on output.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration (T_A = 25°C)	5 sec
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

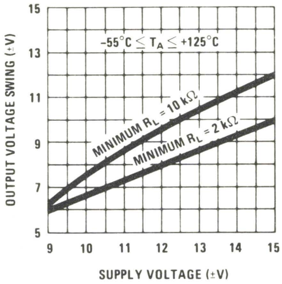
electrical characteristics (Note 2)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		100	500	nA
Input Bias Current	$T_A = 25°C$		0.3	1.5	μA
Input Resistance	$T_A = 25°C$	50	250		kΩ
Output Resistance	$T_A = 25°C$		150		Ω
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		2.6	6.6	mA
Transient Response	$V_{IN} = 20\ mV$, $C_L \leq 100\ pF$				
Risetime	$T_A = 25°C$		0.3	1.0	μs
Overshoot			10	30	%
Slewing Rate	$T_A = 25°C$		0.25		V/μs
Input Offset Voltage	$R_S \leq 10\ k\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\Omega$		6.0		μV/°C
	$R_S = 10\ k\Omega$		12		μV/°C
Large-Signal Voltage Gain	$V_S = \pm 15V$, $R_L \geq 2\ k\Omega$ $V_{OUT} = \pm 10V$	15,000	45,000		
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±12	±14		V
	$V_S = \pm 15V$, $R_L = 2\ k\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm 15V$	±8.0	±10		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	65	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$		25	200	μV/V
Input Offset Current	$T_A = +70°C$		75	400	nA
	$T_A = 0°C$		125	750	nA
Input Bias Current	$T_A = 0°C$		0.36	2.0	μA

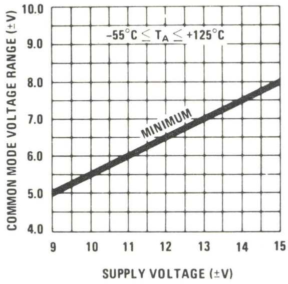
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient for the metal can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.
Note 2: These specifications apply for $0°C \leq T_A \leq +70°C$, $\pm 9V \leq V_S \leq \pm 15V$, C_1 = 5000 pF, R_1 = 1.5K, C_2 = 200 pF and $R_2 = 51\Omega$ unless otherwise specified.

guaranteed performance characteristics

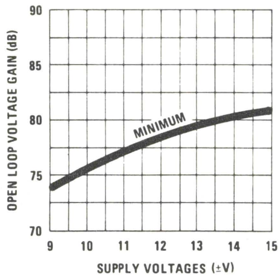
Output Voltage Swing



Input Common Mode Voltage Range

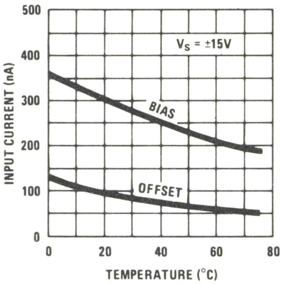


Voltage Gain

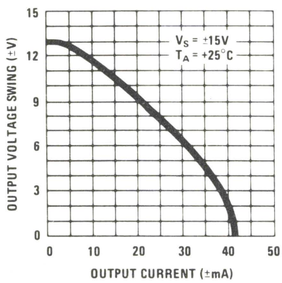


typical performance characteristics

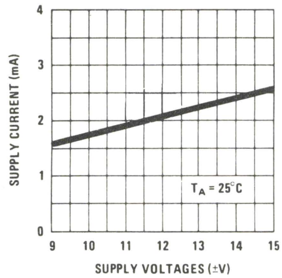
Input Current



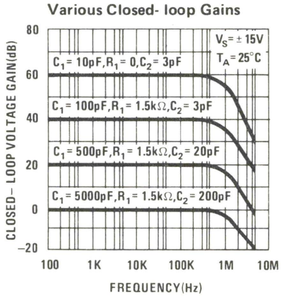
Output Voltage Swing



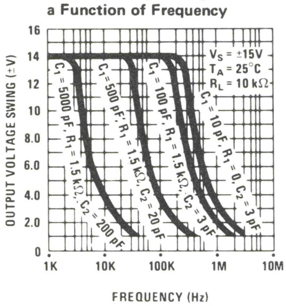
Supply Current



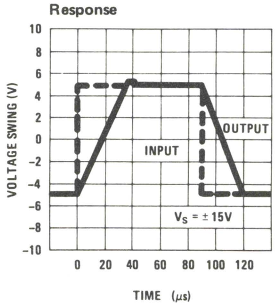
Frequency Responce For Various Closed- loop Gains



Output Voltage Swing as a Function of Frequency



Voltage Follower Pulse Response



Operational Amplifiers

LM725A/LM725/LM725C instrumentation operational amplifier

general description

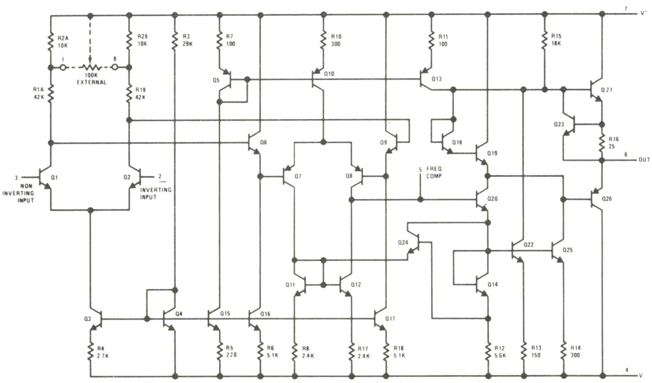
The LM725A/LM725/LM725C are operational amplifiers featuring superior performance in applications where low noise, low drift, and accurate closed-loop gain are required. With high common mode rejection and offset null capability, it is especially suited for low level instrumentation applications over a wide supply voltage range.

The LM725A has tightened electrical performance with higher input accuracy and like the LM725, is guaranteed over a −55°C to +125°C temperature range. The LM725C has slightly relaxed specifications and has its performance guaranteed over a 0°C to 70°C temperature range.

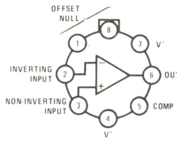
features

- High open loop gain 3,000,000
- Low input voltage drift 0.6 μV/°C
- High common mode rejection 120 dB
- Low input noise current 0.15 pA/$\sqrt{\text{Hz}}$
- Low input offset current 2 nA
- High input voltage range ±14V
- Wide power supply range ±3V to ±22V
- Offset null capability
- Output short circuit protection

schematic and connection diagrams



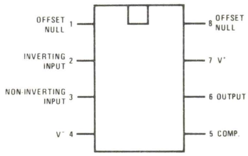
Metal Can Package



TOP VIEW

Order Number LM725H or LM725AH or LM725CH
See Package 11

Dual-In-Line Package

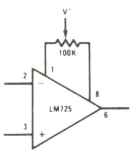


TOP VIEW

Order Number LM725CN
See Package 20

auxiliary circuits

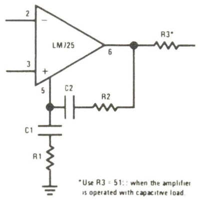
Voltage Offset Null Circuit



Compensation Component Values

A_{VCL}	R1 (Ω)	C1 (μF)	R2 (Ω)	C2 (μF)
10,000	10K	50 pF	–	–
1,000	470	.001	–	–
100	47	.01	–	–
10	27	.05	270	.0015
1	10	.05	39	.02

Frequency Compensation Circuit



LM725A

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25°C$, $R_S \leq 10\ k\Omega$			0.5	mV
Input Offset Current	$T_A = 25°C$		2.0	5.0	nA
Input Bias Current	$T_A = 25°C$		42	80	nA
Input Noise Voltage	$T_A = 25°C$, $f_o = 10\ Hz$		15		$nV/\sqrt{Hz}$
	$f_o = 100\ Hz$		9.0		$nV/\sqrt{Hz}$
	$f_o = 1\ kHz$		8.0		$nV/\sqrt{Hz}$
Input Noise Current	$T_A = 25°C$, $f_o = 10\ Hz$		1.0		$pA/\sqrt{Hz}$
	$f_o = 100\ Hz$		0.3		$pA/\sqrt{Hz}$
	$f_o = 1\ kHz$		0.15		$pA/\sqrt{Hz}$
Input Resistance	$T_A = 25°C$		1.5		MΩ
Input Voltage Range	$T_A = 25°C$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10V$	1,000,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$	120			dB
Power Supply Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		2.0	5.0	μV/V
Output Voltage Swing	$T_A = 25°C$, $R_L \geq 10\ k\Omega$	±12.5	±13.5		V
	$R_L \geq 2\ k\Omega$	±12.0	±13.5		V
Power Consumption	$T_A = 25°C$		80	105	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\ k\Omega$			0.7	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$			2.0	μV/°C
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6	1.0	μV/°C
Input Offset Current	$T_A = +125°C$		1.2	4.0	nA
	$T_A = -55°C$		7.5	18.0	nA
Average Input Offset Current Drift			35	90	pA/°C
Input Bias Current	$T_A = +125°C$		20	70	nA
	$T_A = -55°C$		80	180	nA
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, $T_A = +125°C$	1,000,000			
	$R_L \geq 2\ k\Omega$, $T_A = -55°C$	500,000			
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	110			dB
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$			8.0	μV/V
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±12			V

Note 1: Derate at 150°C/W for operation at ambient temperatures above 75°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15V$ unless otherwise specified.

LM725

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		0.5	1.0	mV
Input Offset Current	$T_A = 25°C$		2.0	20	nA
Input Bias Current	$T_A = 25°C$		42	100	nA
Input Noise Voltage	$T_A = 25°C$, $f_o = 10$ Hz		15		$nV/\sqrt{Hz}$
	$f_o = 100$ Hz		9.0		$nV/\sqrt{Hz}$
	$f_o = 1$ kHz		8.0		$nV/\sqrt{Hz}$
Input Noise Current	$T_A = 25°C$, $f_o = 10$ Hz		1.0		$pA/\sqrt{Hz}$
	$f_o = 100$ Hz		0.3		$pA/\sqrt{Hz}$
	$f_o = 1$ kHz		0.15		$pA/\sqrt{Hz}$
Input Resistance	$T_A = 25°C$		1.5		MΩ
Input Voltage Range	$T_A = 25°C$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10V$	1,000,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$	110	120		dB
Power Supply Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		2.0	10	μV/V
Output Voltage Swing	$T_A = 25°C$, $R_L \geq 10\ k\Omega$	±12	±13.5		V
	$R_L \geq 2\ k\Omega$	±10	±13.5		V
Power Consumption	$T_A = 25°C$		80	105	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\ k\Omega$			1.5	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$		2.0	5.0	μV/°C
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6		μV/°C
Input Offset Current	$T_A = +125°C$		1.2	20	nA
	$T_A = -55°C$		7.5	40	nA
Average Input Offset Current Drift			35	150	pA/°C
Input Bias Current	$T_A = +125°C$		20	100	nA
	$T_A = -55°C$		80	200	nA
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, $T_A = +125°C$	1,000,000			
	$R_L \geq 2\ k\Omega$, $T_A = -55°C$	250,000			
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	100			dB
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$			20	μV/V
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±10			V

Note 1: Derate at 150°C/W for operation at ambient temperatures above 75°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15V$ unless otherwise specified.

LM725C

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mV
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		0.5	2.5	mV
Input Offset Current	$T_A = 25°C$		2.0	35	nA
Input Bias Current	$T_A = 25°C$		42	125	nA
Input Noise Voltage	$T_A = 25°C$, $f_o = 10$ Hz		15		$nV/\sqrt{Hz}$
	$f_o = 100$ Hz		9.0		$nV/\sqrt{Hz}$
	$f_o = 1$ kHz		8.0		$nV/\sqrt{Hz}$
Input Noise Current	$T_A = 25°C$, $f_o = 10$ Hz		1.0		$pA/\sqrt{Hz}$
	$f_o = 100$ Hz		0.3		$pA/\sqrt{Hz}$
	$f_o = 1$ kHz		0.15		$pA/\sqrt{Hz}$
Input Resistance	$T_A = 25°C$		1.5		MΩ
Input Voltage Range	$T_A = 25°C$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10V$	250,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$	94	120		dB
Power Supply Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		2.0	35	μV/V
Output Voltage Swing	$T_A = 25°C$, $R_L \geq 10\ k\Omega$	±12	±13.5		V
	$R_L \geq 2\ k\Omega$	±10	±13.5		V
Power Consumption	$T_A = 25°C$		80	150	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\ k\Omega$			3.5	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$		2.0		μV/°C
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6		μV/°C
Input Offset Current	$T_A = +70°C$		1.2	35	nA
	$T_A = 0°C$		4.0	50	nA
Average Input Offset Current Drift			10		pA/°C
Input Bias Current	$T_A = +70°C$			125	nA
	$T_A = 0°C$			250	nA
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, $T_A = +70°C$	125,000			
	$R_L \geq 2\ k\Omega$, $T_A = 0°C$	125,000			
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$		115		dB
Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$		20		μV/V
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±10			V

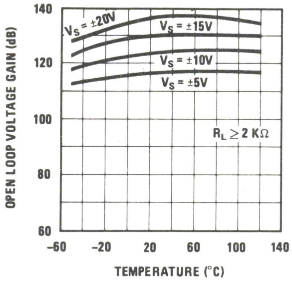
Note 1: Rating applies for case temperature to 70°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

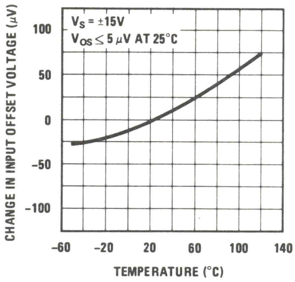
Note 3: These specifications apply for $V_S = \pm 15V$ unless otherwise specified.

typical performance characteristics

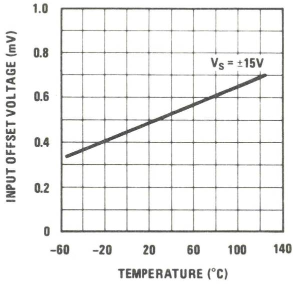
Open Loop Voltage Gain vs Temperature for Various Supply Voltages



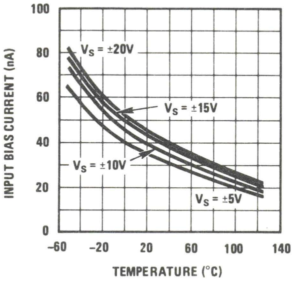
Nulled Input Offset Voltage vs Temperature



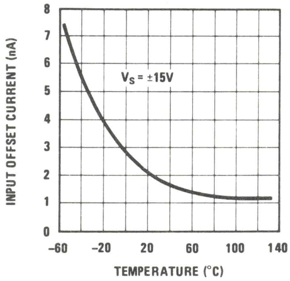
Unnulled Input Offset Voltage vs Temperature



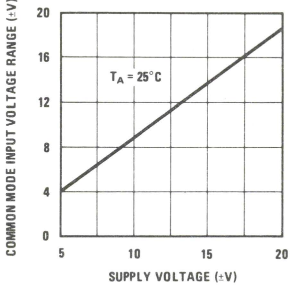
Input Bias Current vs Temperature



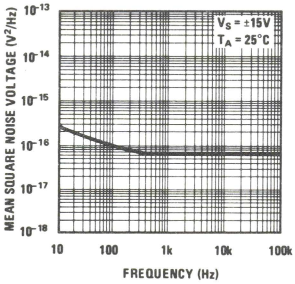
Input Offset Current vs Temperature



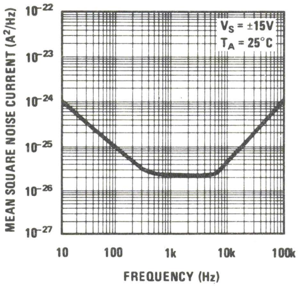
Common Mode Input Voltage vs Supply Voltage



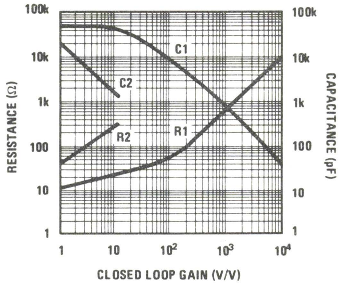
Input Noise Voltage vs Frequency



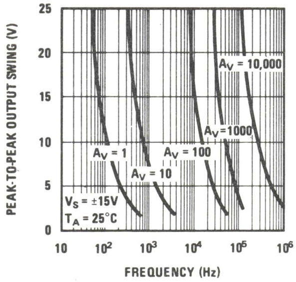
Input Noise Current vs Frequency



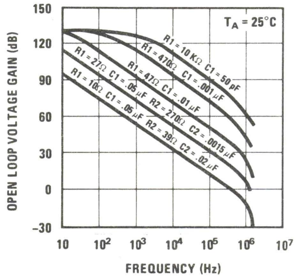
Values for Suggested Compensation Networks for Various Closed Loop Voltage Gains



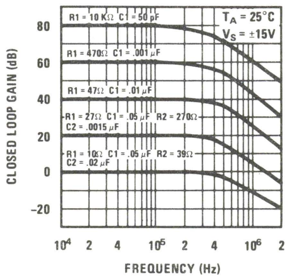
Output Voltage Swing vs Frequency for Recommended Compensation Networks



Open Loop Voltage Gain vs Frequency Using Recommended Compensation Networks

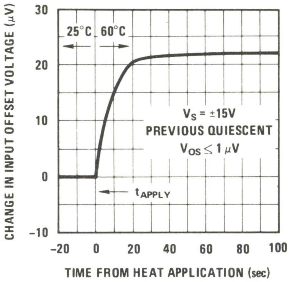


Frequency Response for Various Closed-Loop Gains Using Recommended Compensation Networks

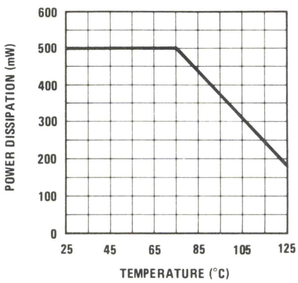


typical performance characteristics (con't)

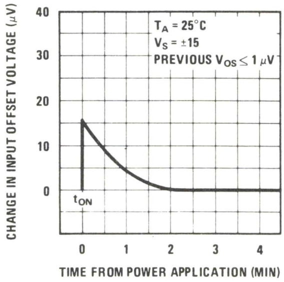
Change in Input Offset Voltage Due to Thermal Shock vs Time



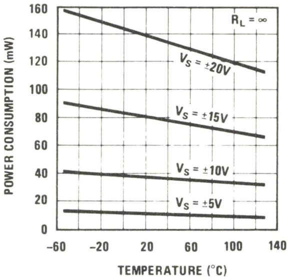
Absolute Maximum Power Dissipation vs Ambient Temperature



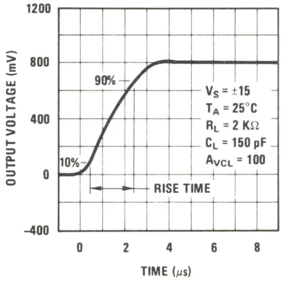
Stabilization Time of Input Offset Voltage from Power Turn-On



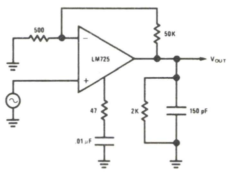
Power Consumption vs Temperature



Transient Response



Transient Response Test Circuit



Operational Amplifiers

LH740A/LH740AC FET input operational amplifier

general description

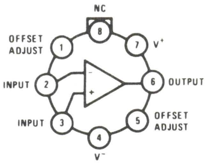
The LH740A/LH740AC is a FET input, general purpose operational amplifier with high input impedance, closely matched input characteristics, and good slew rates. Input offset voltage is typically 10.0 mV at 25°C, while input bias current is less than 100 pA at 25°C. Offset current is typically less than 40 pA at 25°C. Other important design features include:

- Internal 6 dB/octave frequency compensation
- Unity gain slew rate in excess of 6 V/μs
- Unity gain bandwidth of 1 MHz
- Input offset is adjustable with a single 10k pot
- Pin compatible with LM741, LM709, LM101A, and μA740
- Excellent offset current match over temperature, typically 100 pA
- Output is continuously short-circuit proof
- Excellent open loop gain, typically in excess of 100 dB
- Guaranteed over the full military temperature range

The LH740A/LH740AC is intended to fulfill a wide variety of applications requiring extremely low bias currents such as integrators, sample and hold amplifiers, and general purpose operational amplifier applications.

The LH740A is specified for operation over the −55°C to +125°C military temperature range. The LH740AC is specified for operation over the 0°C to +85°C temperature range.

connection diagram



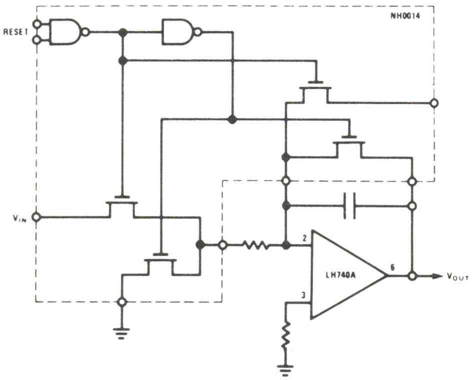
TOP VIEW

Order Number LH740AH or LH740ACH

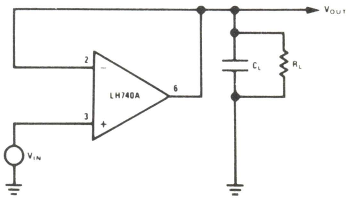
See Package 11

typical applications

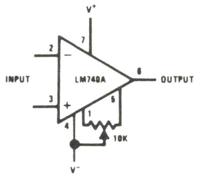
Integrator



Transient Response



Offset Null



absolute maximum ratings

Supply Voltage		±22V
Maximum Power Dissipation		500 mW
Differential Input Voltage		±5V
Input Voltage		±15V
Short Circuit Duration		Continuous
Operating Temperature Range	LH740A	−55°C to +125°C
	LH740AC	0°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (soldering, 10 sec.)		300°C

electrical characteristics (Notes 1 & 2) (V_S = ±15V, T_A = 25°C unless otherwise noted)

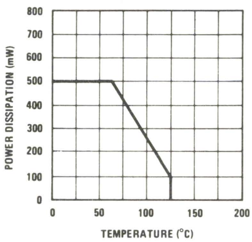
PARAMETER	CONDITIONS	LH740A MIN	LH740A TYP	LH740A MAX	LH740AC MIN	LH740AC TYP	LH740AC MAX	UNITS
Input Offset Voltage	$R_S \leq 100\ k\Omega$		10	15		10	20	mV
Input Offset Current			40	100		60	150	pA
Input Current (either input)			100	200		100	500	pA
Input Resistance			1,000,000			1,000,000		MΩ
Large Signal Voltage Gain	$R_L \geq 2\ k\Omega$, V_{OUT} = ±10V	50,000	100,000		50,000	100,000		V/V
Output Resistance			75			75		Ω
Output Short-Circuit Current			20			20		mA
Common Mode Rejection Ratio		80			80			dB
Supply Voltage Rejection Ratio		80			80			dB
Supply Current			3.0	4.0		3.0	4.0	mA
Slew Rate			6.0			6.0		V/μs
Unity Gain Bandwidth			1.0			1.0		MHz
Transient Response (Unity Gain)	$C_L \leq 100$ pF, R_L = 2 kΩ, V_{IN} = 100 mV							
Risetime			110			300		ns
Overshoot			10	20		10		%
(These specifications apply for $-55°C \leq T_A \leq 125°C$ for the LH740A and $0°C \leq T_A \leq 85°C$ for the LH740AC unless otherwise noted.)								
Input Voltage Range		±12			±12			V
Common Mode Rejection Ratio		80			80			dB
Supply Voltage Rejection Ratio		80			80			dB
Large Signal Voltage Gain		40,000			40,000			V/V
Output Voltage Swing	$R_L \geq 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$	±10	±13		±10	±13		V
Input Offset Voltage			15	20		30		mV
Input Offset Current			100	500		60	500	pA
Input Current (either input)			2.5	4.0		1.1	5.0	nA
Offset Voltage Drift	$R_S \leq 100K$		5.0			5.0		μV/°C

Note 1: Unless otherwise noted these specifications apply to $\pm 5V \leq V_S\ \pm 20V$ and −55°C to +125°C for the LH740A and 0°C to 85°C for the LH740AC.

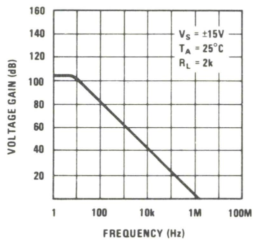
Note 2: For supply voltages less than ±10V, the absolute maximum input voltage is equal to the supply voltage.

typical performance characteristics

Maximum Power Dissipation



Open Loop Frequency Response



Operational Amplifiers

LM741/LM741C operational amplifier

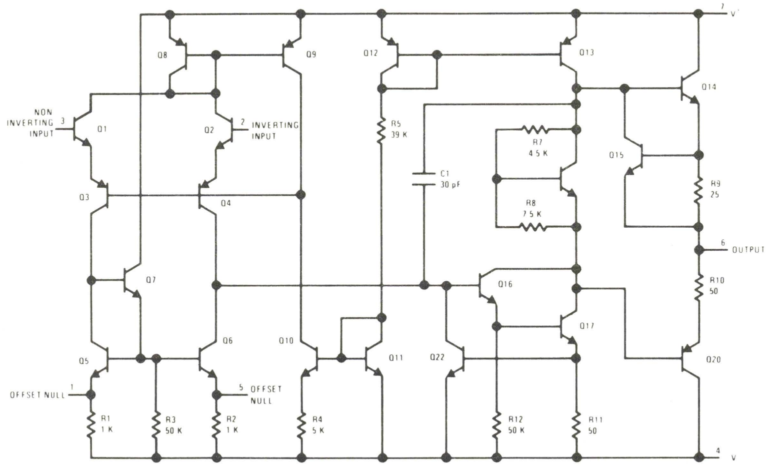
general description

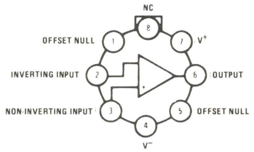
The LM741 and LM741C are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The offset voltage and offset current are guaranteed over the entire common mode range. The amplifiers also offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741 except that the LM741C has its performance guaranteed over a 0°C to 70°C temperature range, instead of −55°C to 125°C.

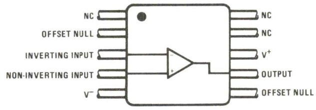
schematic and connection diagrams





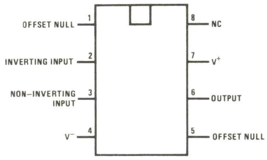
NOTE: Pin 4 connected to case.
TOP VIEW

Order Number LM741H or LM741CH
See Package 11



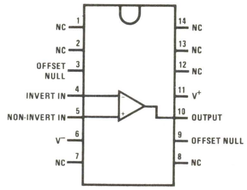
NOTE: Pin 5 connected to bottom of package.
TOP VIEW

Order Number LM741F
See Package 3



TOP VIEW

Order Number LM741CN
See Package 20



TOP VIEW

Order Number
LM741CD or **LM741CN-14**
See Package 1 **See Package 22**

absolute maximum ratings

Supply Voltage	LM741	±22V
	LM741C	±18V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM741	−55°C to 125°C
	LM741C	0°C to 70°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM741			LM741C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25°C$		30	200		30	200	nA
Input Bias Current	$T_A = 25°C$		200	500		200	500	nA
Input Resistance	$T_A = 25°C$	0.3	1.0		0.3	1.0		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm15V$		1.7	2.8		1.7	2.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 2\ k\Omega$	50	160		25	160		V/mV
Input Offset Voltage	$R_S \leq 10\ k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 2\ k\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm15V$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	77	96		77	96		dB

Note 1: The maximum junction temperature of the LM741 is 150°C, while that of the LM741C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to case.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm15V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM741C, however, all specifications are limited to $0°C \leq T_A \leq 70°C$ and $V_S = \pm15V$.

Operational Amplifiers

LM747/LM747C dual operational amplifier

general description

The LM747 and the LM747C are general purpose dual operational amplifiers. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent.

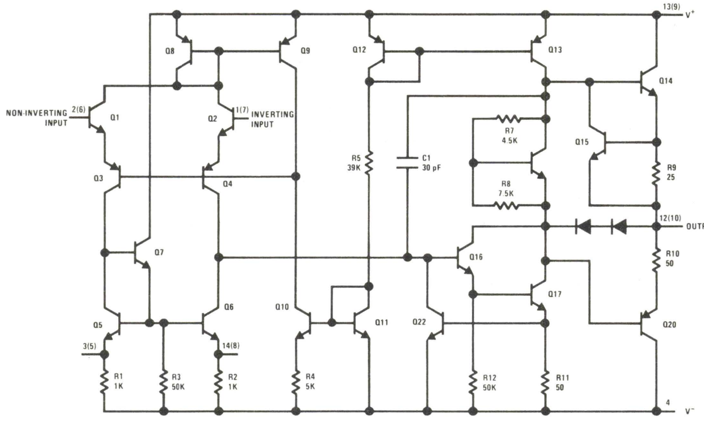
features

- No frequency compensation required
- Short-circuit protection
- Wide common-mode and differential voltage ranges
- Low-power consumption
- No latch-up
- Balanced offset null

Additional features of the LM747 and LM747C are: no latch-up when input common mode range is exceeded, freedom from oscillations, and package flexibility.

The LM747C is identical to the LM747 except that the LM747C has its specifications guaranteed over the temperature range from 0°C to 70°C instead of −55°C to +125°C.

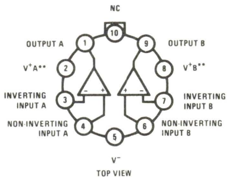
schematic diagram (each amplifier)



Note: Numbers In Parentheses Are Pin Numbers for Amplifier B. DIP Only.

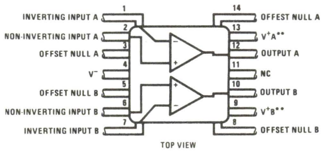
connection diagrams

Metal Can Package



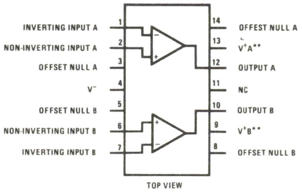
Order Number LM747H or LM747CH
See Package 14

Flat Package



Order Number LM747F or LM747CF
See Package 4

Dual-In-Line Packages



Order Number LM747D or LM747CD
See Package 1
Order Number LM747CN
See Package 22

**V^+A and V^+B are internally connected.

absolute maximum ratings

Supply Voltage	LM747	±22V
	LM747C	±18V
Power Dissipation (Note 1)		800 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM747	−55°C to 125°C
	LM747C	0°C to 70°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM747			LM747C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25°C$		80	200		80	200	nA
Input Bias Current	$T_A = 25°C$		200	500		200	500	nA
Input Resistance	$T_A = 25°C$	0.3	1.0		0.3	1.0		MΩ
Supply Current Both Amplifiers	$T_A = 25°C$, $V_S = \pm 15V$		3.0	5.6		3.0	5.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	160		50	160		V/mV
Input Offset Voltage	$R_S \leq 10\ k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25			25			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L = 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range	$V_S = \pm 15V$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	77	96		77	96		dB

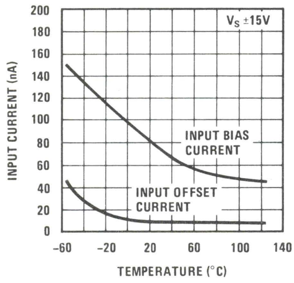
Note 1: The maximum junction temperature of the LM747 is 150°C, while that of the LM747C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

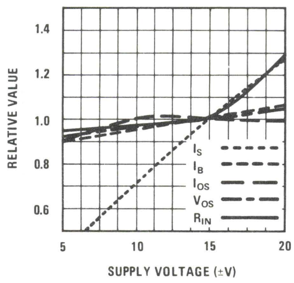
Note 3: These specifications apply for $V_S = \pm 15V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM747C, however, all specifications are limited to $0°C \leq T_A \leq 70°C$ $V_S = \pm 15V$.

typical performance characteristics

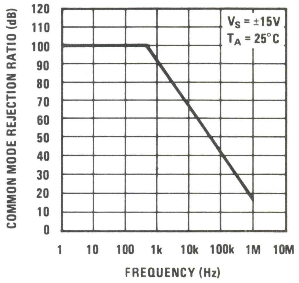
Input Bias and Offset Currents vs Ambient Temperature



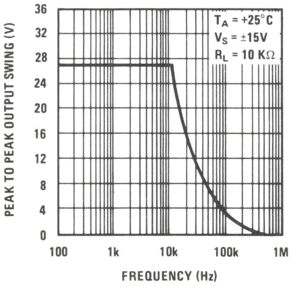
DC Parameters vs Supply Voltage



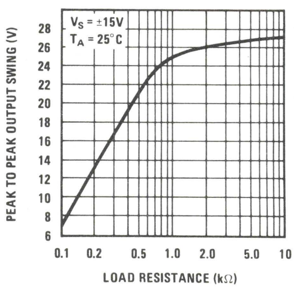
Common Mode Rejection Ratio vs Frequency



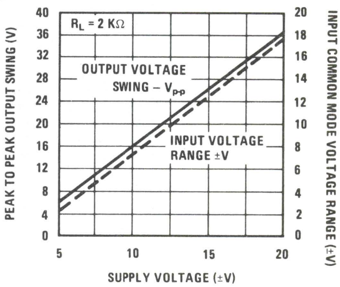
Output Voltage Swing vs Frequency



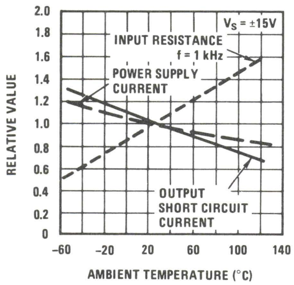
Output Voltage Swing vs Load Resistance



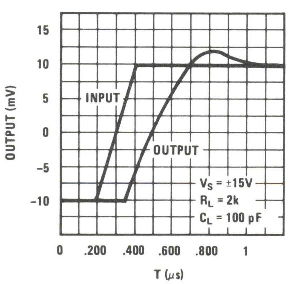
Output Swing and Input Range vs Supply Voltage



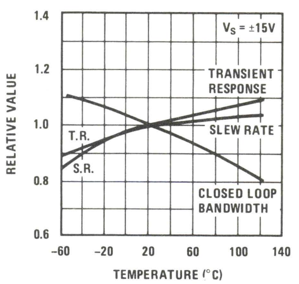
Normalized DC Parameters vs Ambient Temperature



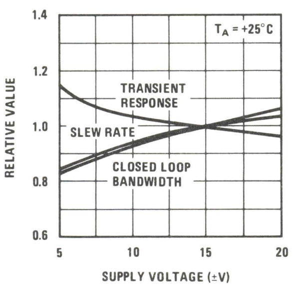
Transient Response



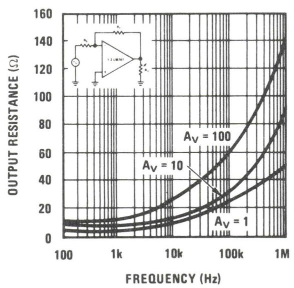
Frequency Characteristics vs Ambient Temperature



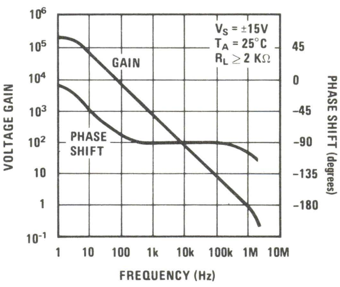
Frequency Characteristics vs Supply Voltage



Output Resistance vs Frequency

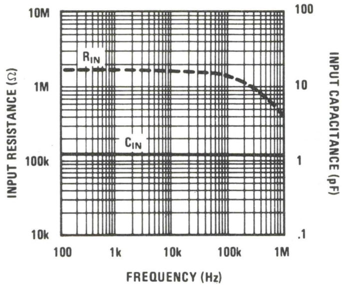


Open Loop Transfer Characteristics vs Frequency

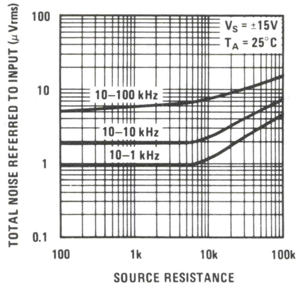


typical performance characteristics (con't)

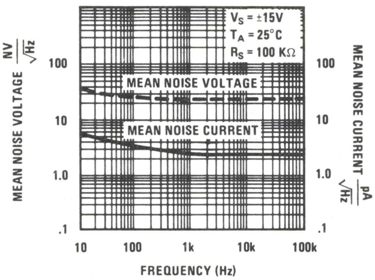
Input Resistance and Input Capacitance vs Frequency



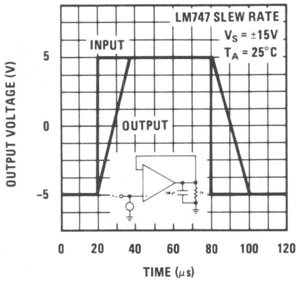
Broadband Noise for Various Bandwidths



Input Noise Voltage and Current vs Frequency



Voltage Follower Large Signal Pulse Response



Operational Amplifiers

LM748/LM748C operational amplifier

general description

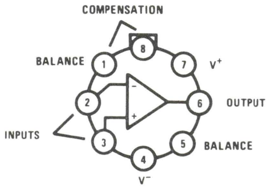
The LM748/LM748C is a general purpose operational amplifier built on a single silicon chip. The resulting close match and tight thermal coupling gives low offsets and temperature drift as well as fast recovery from thermal transients. In addition, the device features:

- Frequency compensation with a single 30 pF capacitor
- Operation from ±5V to ±20V
- Low current drain: 1.8 mA at ±20V
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as ±30V
- No latch-up when common mode range is exceeded.
- Same pin configuration as the LM101.

The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits.

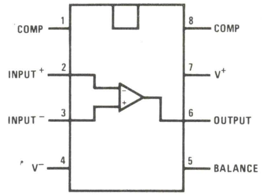
The LM748 is specified for operation over the −55°C to +125°C military temperature range. The LM748C is specified for operation over the 0°C to +70°C temperature range.

connection diagrams



NOTE: Pin 4 connected to case.

Order Number LM748H or LM748CH
See Package 11

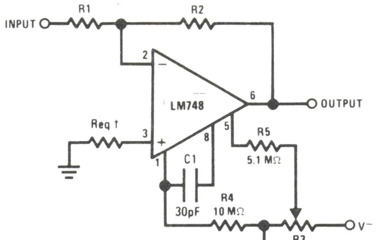


TOP VIEW

Order Number LM748CN
See Package 20

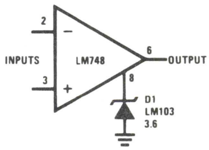
typical applications

Inverting Amplifier with Balancing Circuit

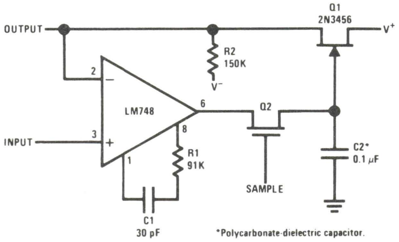


†May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Voltage Comparator for Driving DTL or TTL Integrated Circuits

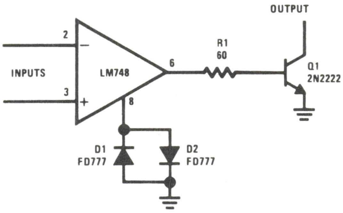


Low Drift Sample and Hold



*Polycarbonate-dielectric capacitor.

Voltage Comparator for Driving RTL Logic or High Current Driver



absolute maximum ratings

Supply Voltage		±22V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration (Note 3)		Indefinite
Operating Temperature Range:	LM748	–55°C to +125°C
	LM748C	0°C to +70°C
Storage Temperature Range		–65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \le 10\ k\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25°C$		40	200	nA
Input Bias Current	$T_A = 25°C$		120	500	nA
Input Resistance	$T_A = 25°C$	300	800		kΩ
Supply Current	$T_A = 25°C$, $V_S = \pm15V$		1.8	2.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \ge 2\ k\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \le 10\ k\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \le 50\Omega$ $R_S \le 10\ k\Omega$		3.0 6.0		μV/°C μV/°C
Input Offset Current	$T_A = 0°C$ to $70°C$ $T_A = -55°C$ to $125°C$			300 500	nA nA
Input Bias Current	$T_A = 0°C$ to $70°C$ $T_A = -55°C$ to $125°C$			0.8 1.5	μA μA
Supply Current	$T_A = +125°C$, $V_S = \pm15V$ $T_A = -55°C$ to $125°C$		1.2 1.9	2.25 3.3	mA mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \ge 2\ K\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm15V$	±12			V
Common Mode Rejection Ratio	$R_S \le 10\ k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \le 10\ k\Omega$	77	90		dB

Note 1: For operating at elevated temperatures the devices must be derated based on a maximum junction to case thermal resistance of 45°C per watt, or 150°C per watt junction to ambient. (See Curves).

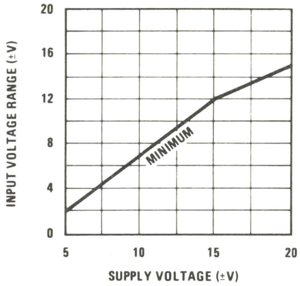
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.

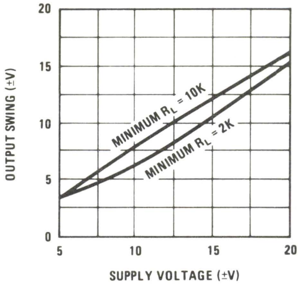
Note 4: These specifications apply for $\pm5V \le V_S \le +15V$ and $-55°C \le T_A \le 125°C$, unless otherwise specified. With the LM748C, however, all temperature specifications are limited to $0°C \le T_A \le 70°C$.

guaranteed performance characteristics (Note 4)

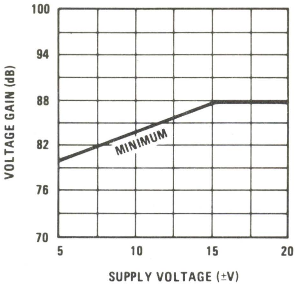
Input Voltage Range



Output Swing

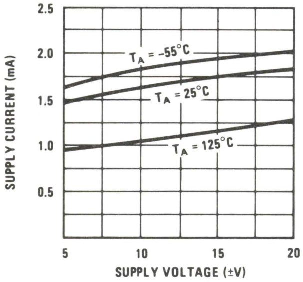


Voltage Gain

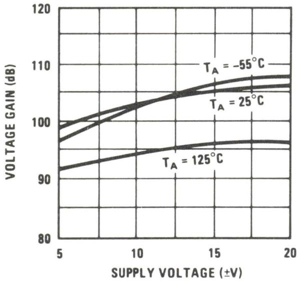


typical performance characteristics

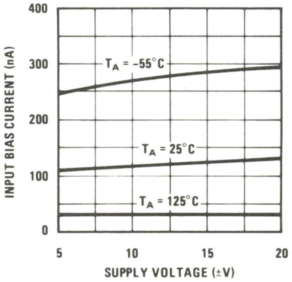
Supply Current



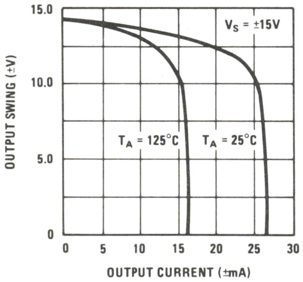
Voltage Gain



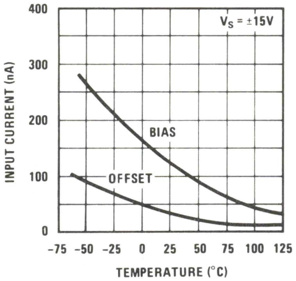
Input Bias Current



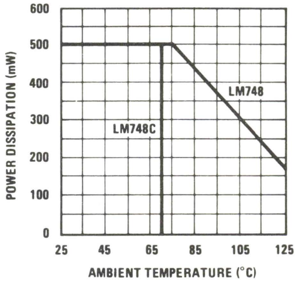
Current Limiting



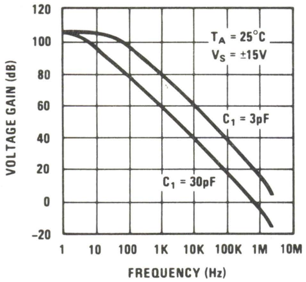
Input Current



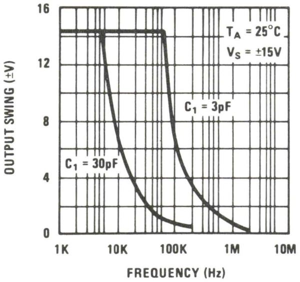
Maximum Power Dissipation



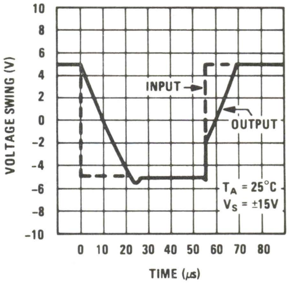
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



Operational Amplifiers

LM1558/LM1458 dual operational amplifier

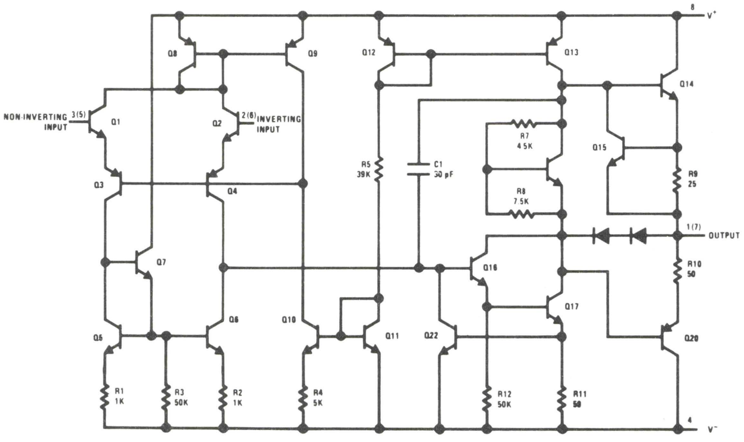
general description

The LM1558 and the LM1458 are general purpose dual operational amplifiers. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent. Features include:

- No frequency compensation required
- Short-circuit protection
- Wide common-mode and differential voltage ranges
- Low-power consumption
- 8-lead TO-5 and 8-lead mini DIP
- No latch up when input common mode range is exceeded

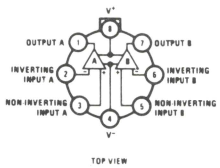
The LM1458 is identical to the LM1558 except that the LM1458 has its specifications guaranteed over the temperature range from 0°C to 70°C instead of −55°C to +125°C.

schematic and connection diagrams



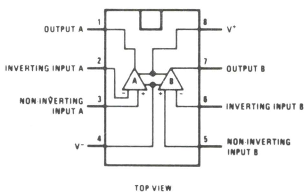
Note: Numbers In Parentheses Are Pin Numbers for Amplifier B.

Metal Can Package



Order Number LM1458H or LM1558H
See Package 11

Dual-In-Line Package



Order Number LM1458N
See Package 20

absolute maximum ratings

Supply Voltage LM1558	±22V	Output Short-Circuit Duration	Indefinite
LM1458	±18V	Operating Temperature Range LM1558	−55°C to 125°C
Power Dissipation (Note 1) LM1558H/LM1458H	500 mW	LM1458	0°C to 70°C
LM1458N	400 mW	Storage Temperature Range	−65°C to 150°C
Differential Input Voltage	±30V	Lead Temperature (Soldering, 10 sec)	300°C
Input Voltage (Note 2)	±15V		

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM1558			LM1458			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 10\ k\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25°C$		80	200		80	200	nA
Input Bias Current	$T_A = 25°C$		200	500		200	500	nA
Input Resistance	$T_A = 25°C$	0.3	1.0		0.3	1.0		MΩ
Supply Current Both Amplifiers	$T_A = 25°C$, $V_S = \pm 15V$		3.0	5.0		3.0	5.6	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	160		20	160		V/mV
Input Offset Voltage	$R_S \leq 10\ k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15V$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	77	96		77	96		dB

Note 1: The maximum junction temperature of the LM1558 is 150°C, while that of the LM1458 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient or 45°C/W, junction to case. For the DIP the device must be derated based on a thermal resistance of 187°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM1458, however, all specifications are limited to $0°C \leq T_A \leq 70°C$ and $V_S = \pm 15V$.

Operational Amplifiers

LH2101A/LH2201A/LH2301A dual high performance op amp

general description

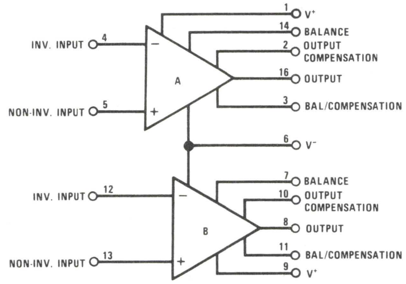
The LH2101A series of dual operational amplifiers are two LM101A type op amps in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost, and smaller size than two singles. For additional information, see the LM101A data sheet and National's Linear Application Handbook.

The LH2101A is specified for operation over the −55°C to +125°C military temperature range. The LH2201A is specified for operation over the −25°C to +85°C temperature range. The LH2301A is specified for operation over the 0°C to +70°C temperature range.

features

- Low offset voltage
- Low offset current
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

connection diagram

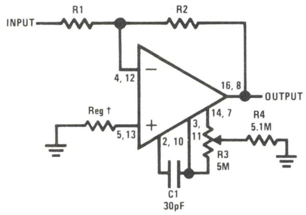


Order Number LH2101AD or LH2201AD or LH2301AD
See Package 2

Order Number LH2101AF or LH2201AF or LH2301AF
See Package 5

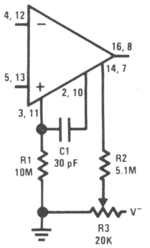
auxiliary circuits

Inverting Amplifier with Balancing Circuit

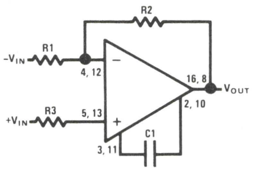


†May be zero or equal to parallel combination of R1 and R2 for minimum offset

Alternate Balancing Circuit



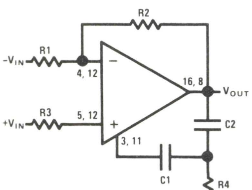
Single Pole Compensation



$C1 \geq \frac{R1\ C_S}{R1 + R2}$

$C_S = 30$ pF

Two Pole Compensation

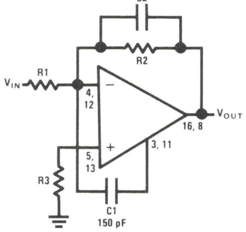


$C1 \geq \frac{R1\ C_S}{R1 + R2}$

$C_S = 30$ pF

$C2 = 10\ C1$

Feedforward Compensation



$C2 = \frac{1}{2\pi f_o R2}$

$f_o = 3$ MHz

absolute maximum ratings

Supply Voltage	±22V	Operating Temperature Range	LH2101A	-55°C to 125°C
Power Dissipation (Note 1)	500 mW		LH2201A	-25°C to 85°C
Differential Input Voltage	±30V		LH2301A	0°C to 70°C
Input Voltage (Note 2)	±15V	Storage Temperature Range		-65°C to 150°C
Output Short-Circuit Duration	Continuous	Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics each side (Note 3)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2101A	LH2201A	LH2301A	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$	2.0	2.0	7.5	mV Max
Input Offset Current	$T_A = 25°C$	10	10	50	nA Max
Input Bias Current	$T_A = 25°C$	75	75	250	nA Max
Input Resistance	$T_A = 25°C$	1.5	1.5	0.5	MΩ Min
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$	3.0	3.3	3.0	mA Max
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	50	25	V/mV Min
Input Offset Voltage	$R_S \leq 50\ k\Omega$	3.0	3.0	10	mV Max
Average Temperature Coefficient of Input Offset Voltage		15	15	30	μV/°C Max
Input Offset Current		20	20	70	nA Max
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 125°C$ $-55°C \leq T_A \leq 25°C$	0.1 0.2	0.1 0.2	0.3 0.6	nA/°C Max nA/°C Max
Input Bias Current		100	100	300	nA Max
Supply Current	$T_A = +125°C$, $V_S = \pm 20V$	2.5	2.5		mA Max
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25	25	15	V/mV Min
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±12 ±10	±12 ±10	V Min V Min
Input Voltage Range	$V_S = \pm 20V$	±15	±15	±12	V Min
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	80	80	70	dB Min
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	80	80	70	dB Min

Note 1: The maximum junction temperature of the LH2101A is 150°C, while that of the LH2201A is 100°C. For operating temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LH2201A, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$. For the LH2301A these specifications apply for $0°C \leq T_A \leq 70°C$, ±5V and $\leq V_S \leq \pm 15V$. Supply current and input voltage range are specified as $V_S = \pm 15V$ for the LH2301A. $C_1 = 30$ pF unless otherwise specified.

2

Operational Amplifiers

LH2108/LH2208/LH2308, LH2108A/LH2208A/LH2308A

dual super beta op amp

general description

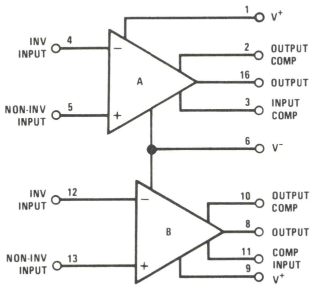
The LH2108A/LH2208A/LH2308A and LH2108/LH2208/LH2308 series of dual operational amplifiers are two LM108A or LM108 type op amps in a single hermetic package. Featuring all the same performance characteristics of the single device, these duals also offer closer thermal tracking, lower weight, reduced insertion cost, and smaller size than two single devices. For additional information see the LM108A or LM108 data sheet and National's Linear Application Handbook.

The LH2108A/LH2108 is specified for operation over the -55°C to +125°C military temperature range. The LH2208A/LH2208 is specified for operation over the -25°C to +85°C temperature range. The LH2308A/LH2308 is specified for operation over the 0°C to +70°C temperature range.

features

■ Low offset current		50 pA
■ Low offset voltage		0.7 mV
■ Low offset voltage	LH2108A	0.3 mV
	LH2108	0.7 mV
■ Wide input voltage range		±15V
■ Wide operating supply range		±3V to ±20V

connection diagram

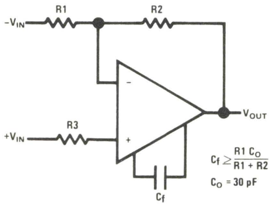


Order Number LH2108AD, LH2208AD, LH2308AD, or LH2108D, LH2208D, or LH2308D
See Package 2

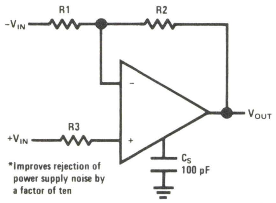
Order Number LH2108F, LH2208F, or LH2308F
See Package 5

auxiliary circuits

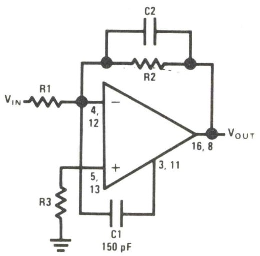
Standard Compensation Circuit



Alternate * Frequency Compensation



Feedforward Compensation



$$C2 = \frac{1}{2\pi f_o R2}$$

$f_o = 3$ MHz

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short Circuit Duration	Continuous
Operating Temperature Range	
LH2108A/LH2108	−55°C to +125°C
LH2208A/LH2208	−25°C to +85°C
LH2308A/LH2308	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2108	LH2208	LH2308	
Input Offset Voltage	$T_A = 25°C$	2.0	2.0	7.5	mV Max
Input Offset Current	$T_A = 25°C$	0.2	0.2	1.0	nA Max
Input Bias Current	$T_A = 25°C$	2.0	2.0	7.0	nA Max
Input Resistance	$T_A = 25°C$	30	30	10	MΩ Min
Supply Current	$T_A = 25°C$	0.6	0.6	0.8	mA Max
Large Signal Voltage Gain	$T_A = 25°C$ $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	50	50	25	V/mV Min
Input Offset Voltage		3.0	3.0	10	mV Max
Average Temperature Coefficient of Input Offset Voltage		15	15	30	μV/°C Max
Input Offset Current		0.4	0.4	1.5	nA Max
Average Temperature Coefficient of Input Offset Current		2.5	2.5	10	pA/°C Max
Input Bias Current		3.0	3.0	10	nA Max
Supply Current	$T_A = +125°C$	0.4	0.4	–	mA Max
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	25	25	15	V/mV Min
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±13	±13	V Min
Input Voltage Range	$V_S = \pm15V$	±13.5	±13.5	±14	V Min
Common Mode Rejection Ratio		85	85	80	dB Min
Supply Voltage Rejection Ratio		80	80	80	dB Min

2

electrical characteristics each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2108A	LH2208A	LH2308A	
Input Offset Voltage	$T_A = 25°C$	0.5	0.5	0.5	mV Max
Input Offset Current	$T_A = 25°C$	0.2	0.2	1.0	nA Max
Input Bias Current	$T_A = 25°C$	2.0	2.0	7.0	nA Max
Input Resistance	$T_A = 25°C$	30	30	10	MΩ Min
Supply Current	$T_A = 25°C$	0.6	0.6	0.8	mA Max
Large Signal Voltage Gain	$T_A = 25°C$ $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 10\ k\Omega$	80	80	80	V/mV Min
Input Offset Voltage		1.0	1.0	0.73	mV Max
Average Temperature Coefficient of Input Offset Voltage		5	5	5	μV/°C Max
Input Offset Current		0.4	0.4	1.5	nA Max
Average Temperature Coefficient of Input Offset Current		2.5	2.5	10	pA/°C Max
Input Bias Current		3.0	3.0	10	nA Max
Supply Current	$T_A = +125°C$	0.4	0.4	–	mA Max
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 10\ k\Omega$	40	40	60	V/mV Min
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±13	±13	±13	V Min
Input Voltage Range	$V_S = \pm15V$	±13.5	±13.5	±14	V Min
Common Mode Rejection Ratio		96	96	96	dB Min
Supply Voltage Rejection Ratio		96	96	96	dB Min

Note 1: The maximum junction temperature of the LH2108A/LH2108 is 150°C, while that of the LH2208A/LH2208 is 100°C and the LH2308A/LH2308 is 85°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce cooper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LH2208A/LH2208, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$ and with the LH2308A/LH2308 for $\pm5V \leq V_S \leq 15V$ and $0°C \leq T_A \leq 70°C$.

Operational Amplifiers

LH2110/LH2210/LH2310 dual voltage follower

general description

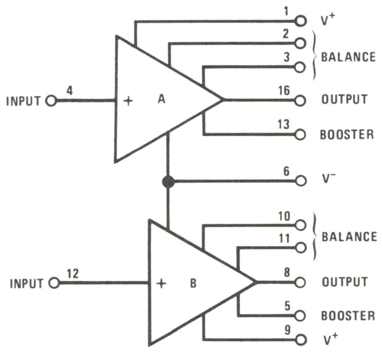
The LH2110 series of dual voltage followers are two LM110 type followers in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost and smaller size than two singles. For additional information, see the LM110 data sheet and National's Linear Application Notebook.

The LH2110 is specified for operation over the −55°C to +125°C military temperature range. The LH2210 is specified for operation over the −25°C to +85°C temperature range. The LH2310 is specified for operation over the 0°C to +70°C temperature range.

features

- Low input current — 1 nA
- High input resistance — 10^{10} ohms
- High slew rate — 30V/µs
- Wide bandwidth — 20 MHz
- Wide operating supply range — ±5V to ±18V
- Output short circuit proof

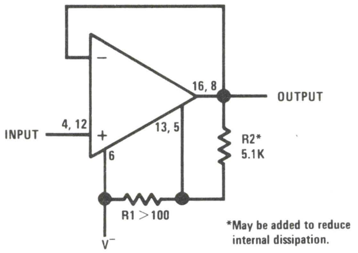
connection diagram



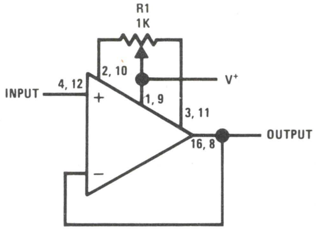
Order Number LH2110D or LH2210D or LH2310D
See Package 2

Order Number LH2110F or LH2210F or LH2310F
See Package 5

auxiliary circuits



Increasing Negative Swing Under Load



Offset Balancing Circuit

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Continuous
Operating Temperature Range LH2110	−55°C to 125°C
LH2210	−25°C to 85°C
LH2310	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics Each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2110	LH2210	LH2310	
Input Offset Voltage	$T_A = 25°C$	4.0	4.0	7.5	mV Max
Input Bias Current	$T_A = 25°C$	3.0	3.0	7.0	nA Max
Input Resistance	$T_A = 25°C$	10^{10}	10^{10}	10^{10}	Ω Min
Input Capacitance		1.5	1.5	1.5	pF Typ
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L = 8\ k\Omega$	.999	.999	.999	V/V Min
Output Resistance	$T_A = 25°C$	2.5	2.5	2.5	Ω Max
Supply Current (Each Amplifier)	$T_A = 25°C$	5.5	5.5	5.5	mA Max
Input Offset Voltage		6.0	6.0	10	mV Max
Offset Voltage Temperature Drift	$-55°C \leq T_A \leq 85°C$ $T_A = 125°C$	6 12	6 12	10 –	μV/°C Typ μV/°C Typ
Input Bias Current		10	10	10	nA Max
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L = 10\ k\Omega$	.999	.999	.999	V/V Min
Output Voltage Swing (Note 5)	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±10	±10	±10	V Min
Supply Current (Each Amplifier)	$T_A = 125°C$	4.0	4.0	–	mA Max
Supply Voltage Rejection Ratio	$\pm 5V \leq V_S \leq \pm 18V$	70	70	70	dB Min

Note 1: The maximum junction temperature of the LH2110 is 150°C, while that of the LH2210 is 100°C and the LH2310 is 85°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 70°C. It is necessary to insert a resistor greater than 2 kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $\pm 5V \leq V_S \leq \pm 18V$ and $-55°C \leq T_A \leq 125°C$, unless otherwise specified. With the LM210, however, all temperature specifications are limited to $-25°C \leq T_A \leq 85°C$ and for the LH2310, all temperature specifications are limited to $0°C \leq T_A \leq 70°C$.

Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V^- terminals.

Operational Amplifiers

LH2111/LH2211/LH2311 dual voltage comparator

general description

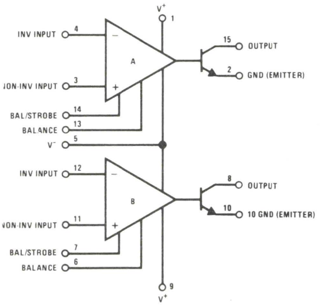
The LH2111 series of dual voltage comparators are two LM111 type comparators in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost and smaller size than two singles. For additional information see the LM111 data sheet and National's Linear Application Handbook.

The LH2111 is specified for operation over the −55°C to +125°C military temperature range. The LH2211 is specified for operation over the −25°C to +85°C temperature range. The LH2311 is specified for operation over the 0°C to 70°C temperature range.

features

- Wide operating supply range — ±15V to a single +5V
- Low input currents — 6 nA
- High sensitivity — 10 μV
- Wide differential input range — ±30V
- High output drive — 50 mA, 50V

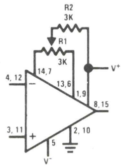
connection diagram



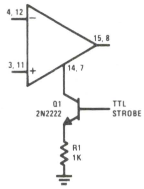
Order Number LH2111D or LH2211D or LH2311D
See Package 2

Order Number LH2111F or LH2211F or LH2311F
See Package 5

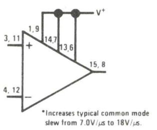
auxiliary circuits



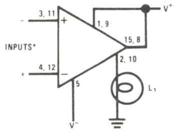
Offset Balancing



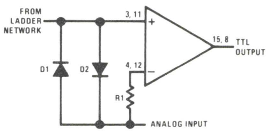
Strobing



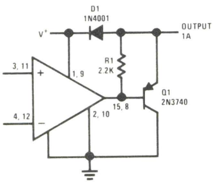
Increasing Input Stage Current*



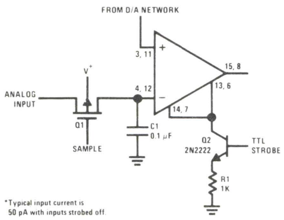
Driving Ground-Referred Load



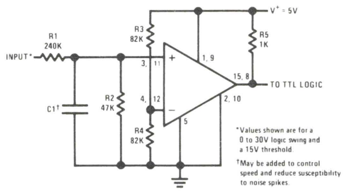
Using Clamp Diodes to Improve Responses



Comparator and Solenoid Driver



Strobing off Both Input* and Output Stages



TTL Interface with High Level Logic

absolute maximum ratings

Total Supply Voltage ($V^+ - V^-$)	36V
Output to Negative Supply Voltage ($V_{OUT} - V^-$)	50V
Ground to Negative Supply Voltage (GND − V^-)	30V
Differential Input Voltage	±30V
Input Voltage (Note 1)	±15V
Power Dissipation (Note 2)	500 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range LH2111	−55°C to 125°C
LH2211	−25°C to 85°C
LH2311	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics — each side (Note 3)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2111	LH2211	LH2311	
Input Offset Voltage (Note 4)	$T_A = 25°C$, $R_S \le 50k$	3.0	3.0	7.5	mV Max
Input Offset Current (Note 4)	$T_A = 25°C$	10	10	50	nA Max
Input Bias Current	$T_A = 25°C$	100	100	250	nA Max
Voltage Gain	$T_A = 25°C$	200	200	200	V/mV Typ
Response Time (Note 5)	$T_A = 25°C$	200	200	200	ns Typ
Saturation Voltage	$V_{IN} \le -5$ mV, $I_{OUT} = 50$ mA $T_A = 25°C$	1.5	1.5	1.5	V Max
Strobe On Current	$T_A = 25°C$	3.0	3.0	3.0	mA Typ
Output Leakage Current	$V_{IN} \ge 5$ mV, $V_{OUT} = 35V$ $T_A = 25°C$	10	10	50	nA Max
Input Offset Voltage (Note 4)	$R_S \le 50k$	4.0	4.0	10	mV Max
Input Offset Current (Note 4)		20	20	70	nA Max
Input Bias Current		150	150	300	nA Max
Input Voltage Range		±14	±14	±14	V Typ
Saturation Voltage	$V^+ \ge 4.5V$, $V^- = 0$ $V_{IN} \le -5$ mV, $I_{SINK} \le 8$ mA	0.4	0.4	0.4	V Max
Positive Supply Current	$T_A = 25°C$	6.0	6.0	7.5	mA Max
Negative Supply Current	$T_A = 25°C$	5.0	5.0	5.0	mA Max

Note 1: This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 2: The maximum junction temperature is 150°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2 ounce copper conductor. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 3: These specifications apply for $V_S = \pm15V$ and $-55°C \le T_A \le 125°C$ for the LH2111, $-25°C \le T_A \le 85°C$ for the LH2211, and $0°C \le T_A \le 70°C$ for the LH2311, unless otherwise stated. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies. For the LH2311, $V_{IN} = \pm10$ mV.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.

Operational Amplifiers

LM2900 quad amplifier

general description

The LM2900 consists of four independent, dual input, internally compensated amplifiers which were designed specifically for automctive and industrial applications. They operate off a single power supply voltage and provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function.

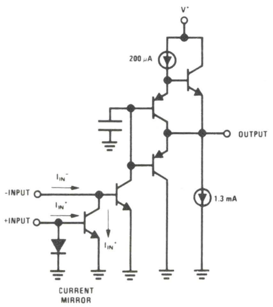
Applications include: AC amplifiers, RC active filters; low frequency triangle, squarewave and pulse waveform generation circuits; tachometers and low speed, high voltage digital logic gates.

For additional information, see Application Note 72, "The LM3900 – A New Current-Differencing Quad of ± Input Amplifiers."

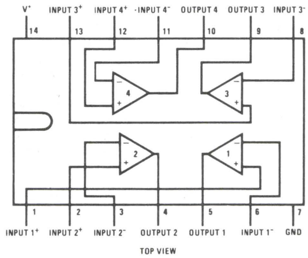
features

- Wide single supply voltage range $4\ V_{DC}$ to $36\ V_{DC}$
- Supply current drain independent of supply voltage
- Low input biasing current 30 nA
- High open-loop gain 70 dB
- Wide bandwidth 2.5 MHz (Unity Gain)
- Larger gain-bandwidth product in non-inverting mode (A_V = 100 @ f = 1 MHz)
- Large output voltage swing $(V^+ -1)\ V_{p\text{-}p}$
- Internally frequency compensated for unity gain
- Output short-circuit protection
- Eliminates need for dual supplies
- Reduces package count

schematic and connection diagrams

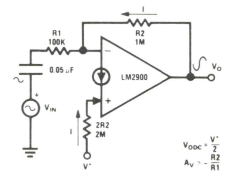


Dual-In-Line Package

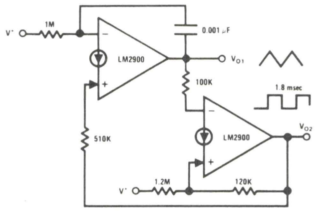


Order Number LM2900N
See Package 22

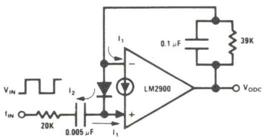
typical applications $(V^+ = 15V_{DC})$



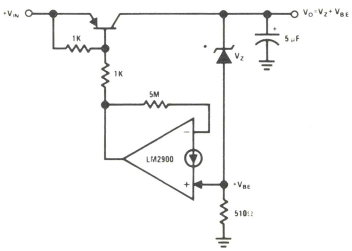
Inverting Amplifier



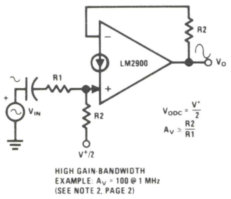
Triangle/Square Generator



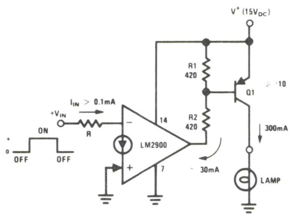
Frequency-Doubling Tachometer



Low V_{IN}–V_{OUT} Voltage Regulator



Non-Inverting Amplifier



Boosting to 300 mA Loads

absolute maximum ratings

Supply Voltage	$+36\ V_{DC}$ $\pm 18\ V_{DC}$
Power Dissipation ($T_A = 25°C$) (Note 1)	570 mW
Input Currents, I_{IN^+} or I_{IN^-}	20 mA DC
Output Short Circuit Duration – One Amplifier $T_A = 25°C$ (See Application Hints)	Continuous
Operating Temperature Range	$-40°C$ to $+85°C$
Storage Temperature Range	$-65°C$ to $+150°C$
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V^+ = +15\ V_{DC}$ and $T_A = 25°C$ unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Open Loop					
Voltage Gain	f = 100 Hz	1200	2800		V/V
Input Resistance	Inverting Input		1		MΩ
Output Resistance			8		kΩ
Unity Gain Bandwidth	Inverting Input (Note 2)		2.5		MHz
Input Bias Current	Inverting Input		30	200	nA
Slew Rate	Positive Output Swing		0.5		V/μs
	Negative Output Swing		20		V/μs
Supply Current	$R_L = \infty$ On All Amplifiers		6.2	10	mA DC
Output Voltage Swing	$R_L = 5.1k$				
V_{OUT} High	$I_{IN^-} = 0$, $I_{IN^+} = 0$	13.5	14.2		V_{DC}
V_{OUT} Low	$I_{IN^-} = 10\ \mu A$, $I_{IN^+} = 0$		0.09	0.2	V_{DC}
Output Current Capability					
Source		3	18		mA DC
Sink	(Note 3)	0.5	1.3		mA DC
Power Supply Rejection	f = 100 Hz		70		dB
Mirror Gain	$I_{IN^+} = 200\ \mu A$ (Note 4)	0.90	1	1.1	μA/μA
Mirror Current	(Note 5)		10	500	μA DC
Negative Input Current	(Note 6)		1.0		mA DC

Note 1: For operating at high temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient.

Note 2: When used as a "non-inverting amplifier" (see bottom of page 1) the gain-bandwidth product is not limited to 2.5 MHz. The isolation provided by the "current mirror" allows a constant unity voltage gain feedback for the main inverting amplifier. This means that large values of gain can be achieved at high frequencies and the dominate limit is due to the slew rate of the amplifier. For example: a voltage gain of 100 is easily obtained at 1 MHz and an output voltage swing of 160 mVp-p can be achieved prior to slew rate limiting. This operational mode is useful for signal frequencies in the 50 kHz to 1 MHz range as would be encountered in IF or carrier frequency applications.

Note 3: The output current sink capability can be increased for large signal conditions by overdriving the inverting input. This is shown in the section on Typical Characteristics.

Note 4: This spec indicates the current gain of the current mirror which is used as the non-inverting input.

Note 5: Input V_{BE} match between the non-inverting and the inverting inputs occurs for a mirror current (non-inverting input current) of approximately 10 μA. This is therefore a typical design center for many of the application circuits.

Note 6: Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately $-0.3\ V_{DC}$. The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA. Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; for example, see the "Differentiator Circuit" in the applications section.

Operational Amplifiers

LM3900 quad amplifier

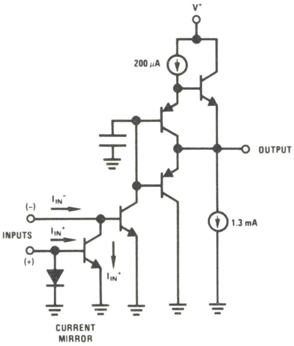
general description

The LM3900 consists of four independent, dual input, internally compensated amplifiers which were designed specifically to operate off of a single power supply voltage and to provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function. Application areas include: AC amplifiers, RC active filters; low frequency triangle, squarewave and pulse waveform generation circuits, tachometers and low speed, high voltage digital logic gates.

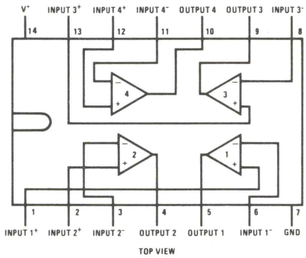
features

- Wide single supply voltage range $4\ V_{DC}$ to $36\ V_{DC}$ or dual supplies $\pm 2\ V_{DC}$ to $\pm 18\ V_{DC}$
- Supply current drain independent of supply voltage
- Low input biasing current 30 nA
- High open-loop gain 70 dB
- Wide bandwidth 2.5 MHz (Unity Gain)
- Large output voltage swing $(V^+ - 1)\ V_{p\text{-}p}$
- Internally frequency compensated for unity gain
- Output short-circuit protection

schematic and connection diagrams

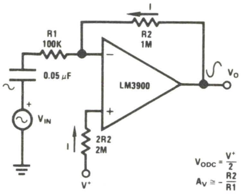


Dual-In-Line Package

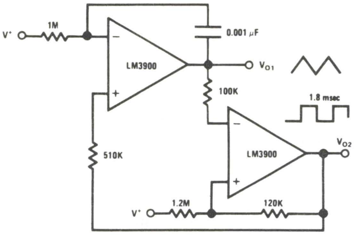


Order Number LM3900N
See Package 22

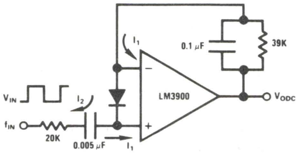
typical applications ($V^+ = 15V_{DC}$)



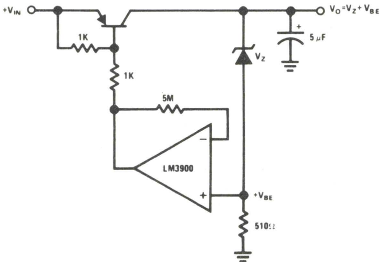
Inverting Amplifier



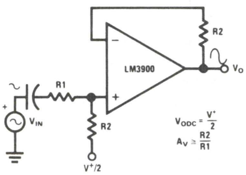
Triangle/Square Generator



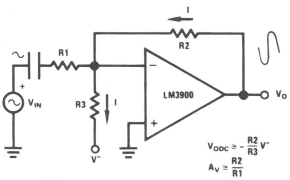
Frequency-Doubling Tachometer



Low V_{IN}–V_{OUT} Voltage Regulator



Non-Inverting Amplifier



Negative Supply Biasing

absolute maximum ratings

Supply Voltage	+36 VDC
	±18 VDC
Power Dissipation (T_A = 25°C) (Note 1)	570 mW
Input Currents, I_{IN^+} or I_{IN^-}	20 mA DC
Output Short Circuit Duration – One Amplifier T_A = 25°C (See Application Hints)	Continuous
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (V⁺ = +15 VDC and T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Open Loop					
Voltage Gain	f = 100 Hz	1200	2800		V/V
Input Resistance	Inverting Input		1		MΩ
Output Resistance			8		kΩ
Unity Gain Bandwidth	Inverting Input		2.5		MHz
Input Bias Current	Inverting Input		30	200	nA
Slew Rate	Positive Output Swing		0.5		V/μs
	Negative Output Swing		20		V/μs
Supply Current	$R_L = \infty$ On All Amplifiers		6.2	10	mA DC
Output Voltage Swing	R_L = 5.1k				
V_{OUT} High	$I_{IN^-} = 0$, $I_{IN^+} = 0$	13.5	14.2		VDC
V_{OUT} Low	$I_{IN^-} = 10\,\mu A$, $I_{IN^+} = 0$		0.09	0.2	VDC
Output Current Capability					
Source		3	18		mA DC
Sink	(Note 2)	0.5	1.3		mA DC
Power Supply Rejection	f = 100 Hz		70		dB
Mirror Gain	$I_{IN^+} = 200\,\mu A$ (Note 3)	0.9	1	1.1	μA/μA
Mirror Current	(Note 4)		10	500	μA DC
Negative Input Current	(Note 5)		1.0		mA DC

Note 1: For operating at high temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient.

Note 2: The output current sink capability can be increased for large signal conditions by overdriving the inverting input. This is shown in the section on Typical Characteristics.

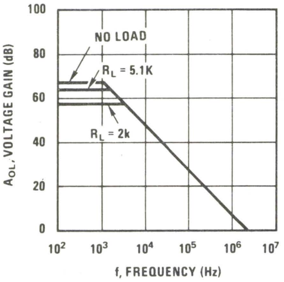
Note 3: This spec indicates the current gain of the current mirror which is used as the non-inverting input.

Note 4: Input V_{BE} match between the non-inverting and the inverting inputs occurs for a mirror current (non-inverting input current) of approximately 10 μA. This is therefore a typical design center for many of the application circuits.

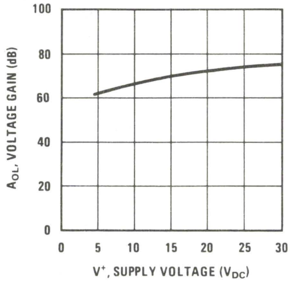
Note 5: Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately −0.3 VDC. The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA. Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; see for example the "Differentiator Circuit" in the applications section.

typical performance characteristics

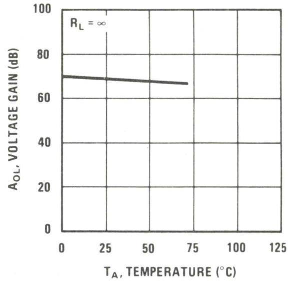
Open-Loop Gain



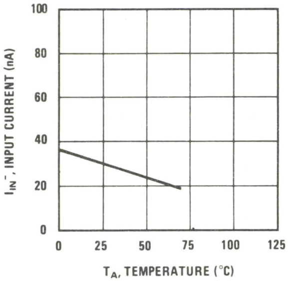
Voltage Gain



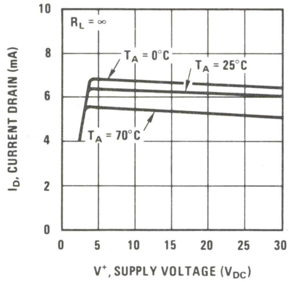
Voltage Gain



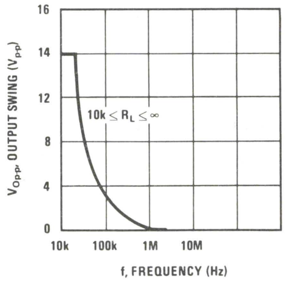
Input Current



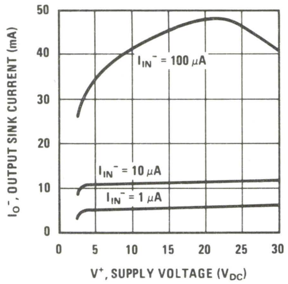
Supply Current



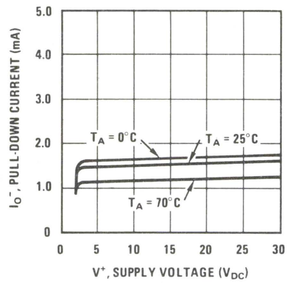
Large Signal Frequency Response



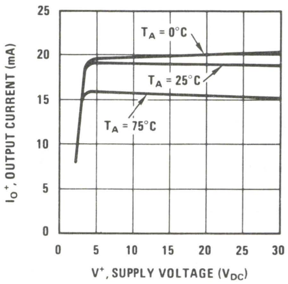
Output Sink Current



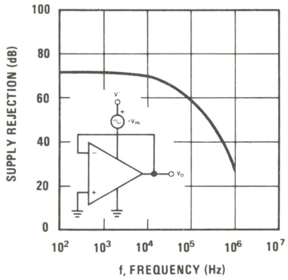
Output Class-A Bias Current



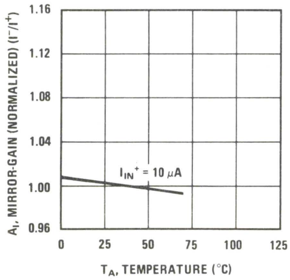
Output Souce Current



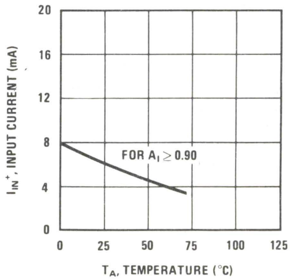
Supply Rejection



Mirror Gain



Maximum Mirror Current



application hints

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak input current. Currents as large as 20 mA will not damage the device, but the current mirror on the non-inverting input will saturate and cause a loss of mirror gain at mA current levels – especially at high operating temperatures.

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fuzing of the internal conductors and result in a destroyed unit.

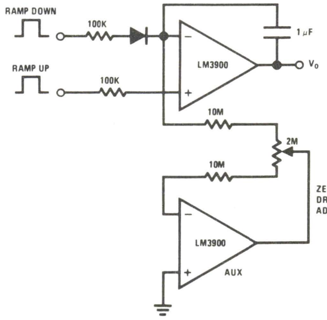
Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fuzing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. For example, when operating from a well-regulated +15 VDC power supply at T_A = 25°C with a 100 kΩ shunt-feedback resistor (from the output to the inverting input) a short directly to the power supply will not cause catastrophic failure but the current magnitude will be approximately 50 mA and the junction temperature will be above T_J max. Larger feedback resistors will reduce the current, 11 MΩ provides approximately 30 mA, an open circuit provides 1.3 mA, and a direct connection from the output to the non-inverting input will result in catastrophic failure when the output is shorted to V^+ as this then places the base-emitter junction of the input transistor directly across the power supply. Short-circuits to ground will have magnitudes of approximately 30 mA and will not cause catastrophic failure at T_A = 25°C.

Unintentional signal coupling from the output to the non-inverting input can cause oscillations. This is likely only in breadboard hook-ups with long component leads and can be prevented by a more careful lead dress or by locating the non-inverting input biasing resistor close to the IC. A quick check of this condition is to bypass the non-inverting input to ground with a capacitor. High impedance biasing resistors used in the non-inverting input circuit make this input lead highly susceptible to unintentional AC signal pickup.

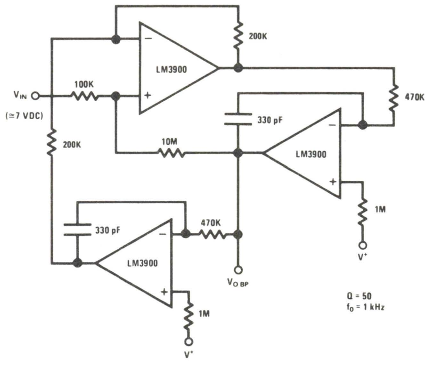
Operation of this amplifier can be best understood by noticing that input currents are differenced at the inverting-input terminal and this difference current then flows through the external feedback resistor to produce the output voltage. Common mode current biasing is generally useful to allow operating with signal levels near ground or even negative as this maintains the inputs biased at $+V_{BE}$. Internal clamp transistors (see note 5) catch negative input voltages at approximately −0.3 VDC but the magnitude of current flow has to be limited by the external input network. For operation at high temperature, this limit should be approximately 100 μA.

This new "Norton" current-differencing amplifier can be used in most of the applications of a standard IC op amp. Performance as a DC amplifier using only a single supply is not as precise as a standard IC op amp operating with split supplies but is adequate in many less critical applications. New functions are made possible with this amplifier which are useful in single power supply systems. For example, biasing can be designed separately from the AC gain as was shown in the "inverting amplifier", the "difference integrator" allows controlling the charging and the discharging of the integrating capacitor using only positive voltages, and the "frequency doubling tachometer" provides a simple circuit which reduces the ripple voltage on a tachometer output DC voltage.

typical applications (con't)

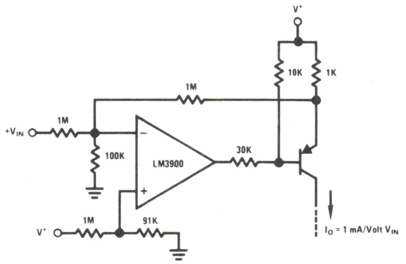


Low-Drift Ramp & Hold Circuit

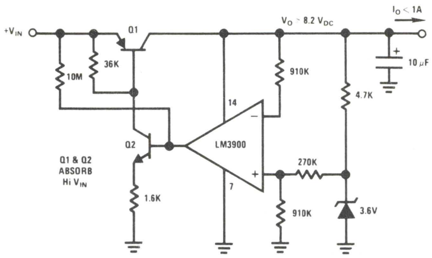


Bi-Quad Active Filter
(2nd Degree State-Variable Network)

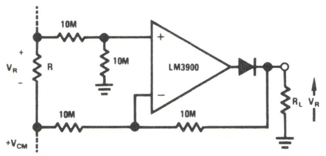
typical applications (con't)



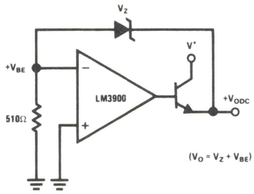
Voltage-Controlled Current Source
(Transconductance Amplifier)



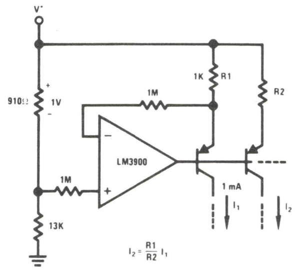
Hi V_{IN}, Lo (V_{IN}–V_O) Self-Regulator



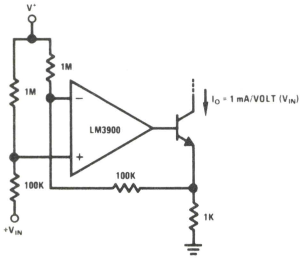
Ground-Referencing a
Differential Input Signal



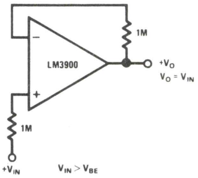
Voltage Regulator



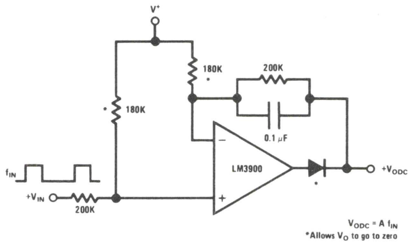
Fixed Current Sources



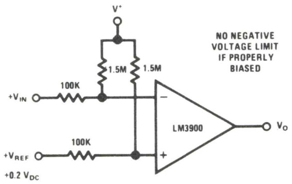
Voltage-Controlled Current Sink
(Transconductance Amplifier)



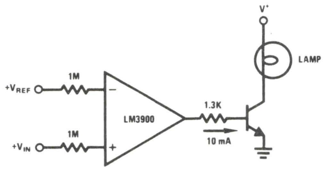
Buffer Amplifier



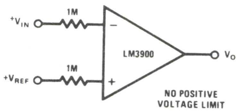
Tachometer



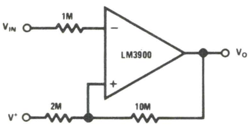
Low-Voltage Comparator



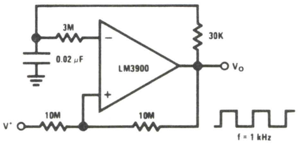
Power Comparator



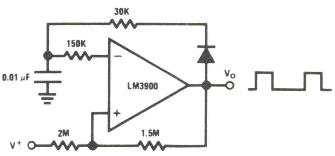
Comparator



Schmitt-Trigger

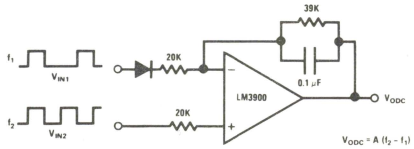


Square-Wave Oscillator

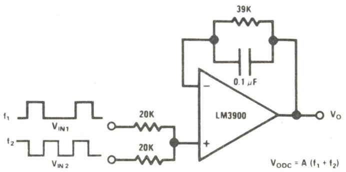


Pulse Generator

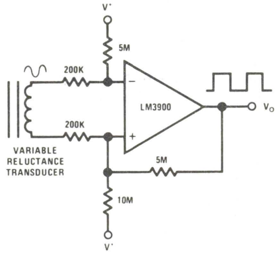
typical applications (con't)



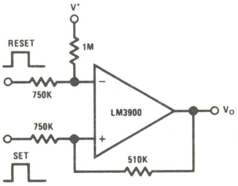
Frequency Differencing Tachometer



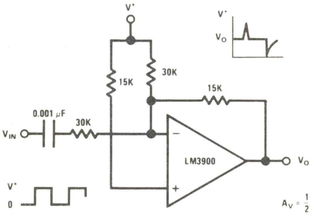
Frequency Averaging Tachometer



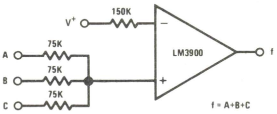
Squaring Amplifier (W/Hysteresis)



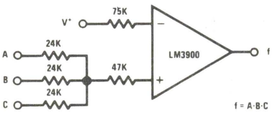
Bi-Stable Multivibrator



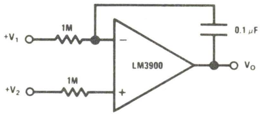
Differentiator (Common-Mode Biasing Keeps Input at $+V_{BE}$)



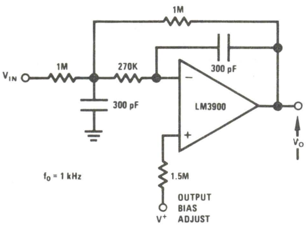
"OR" Gate



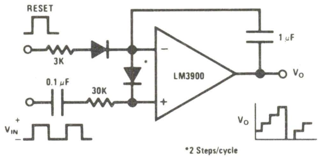
"AND" Gate



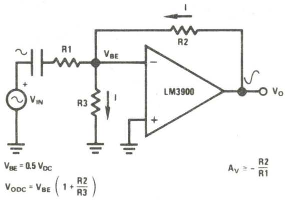
Difference Integrator



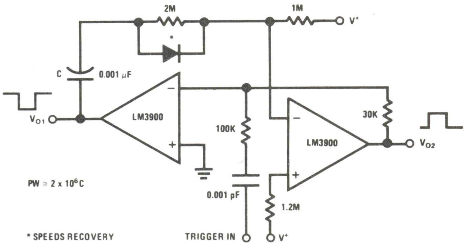
Low Pass Active Filter



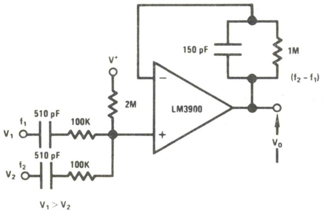
Staircase Generator



V_{BE} Biasing

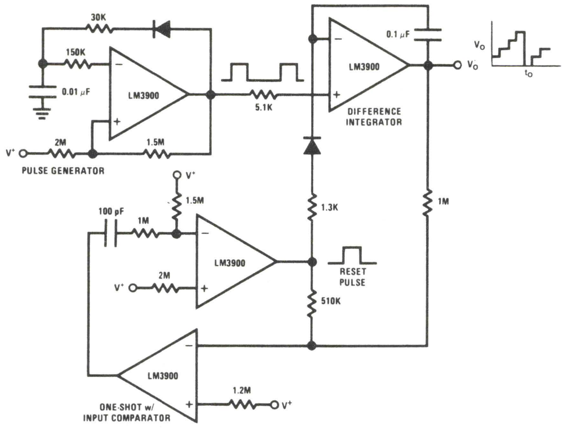


One-Shot Multivibrator

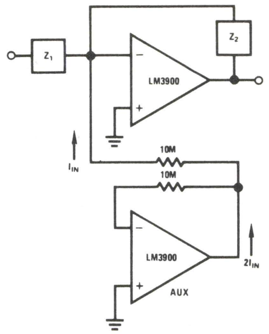


Low-Frequency Mixer

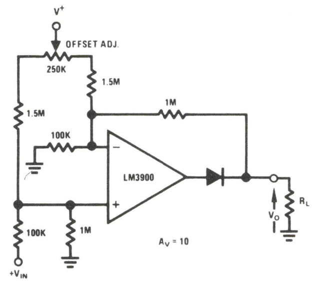
typical applications (con't)



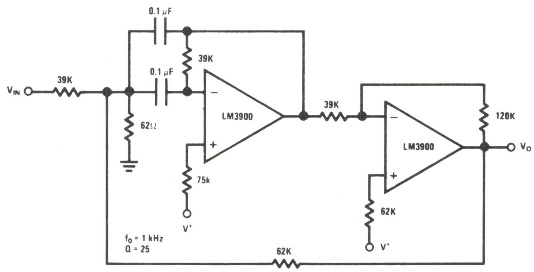
Free-Running Staircase Generator/Pulse Counter



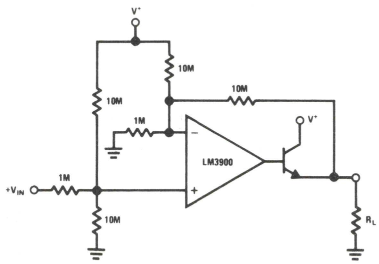
Supplying I_{IN} with Aux. Amp
(to Allow High Z Feedback Networks)



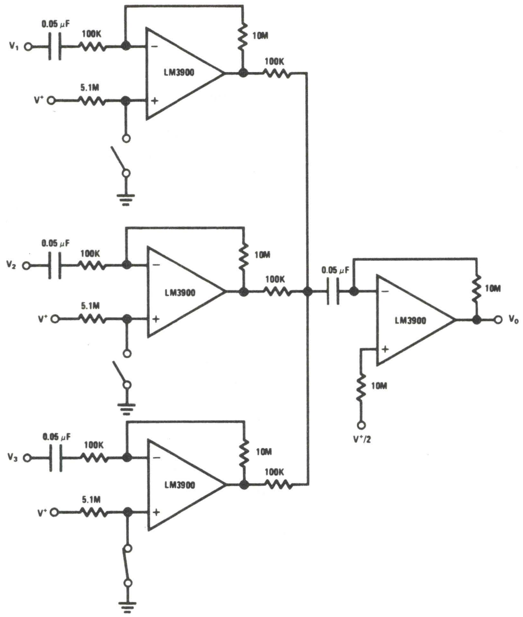
Non-Inverting DC Gain to (0,0)



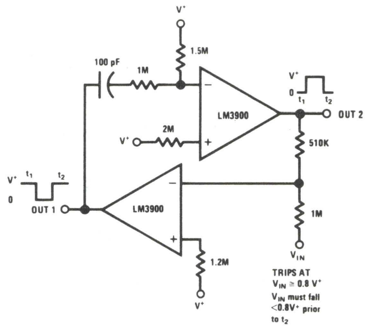
Bandpass Active Filter



Power Amplifier

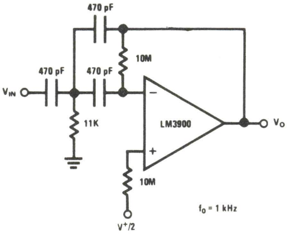


Channel Selection by DC Control
(or Audio Mixer)

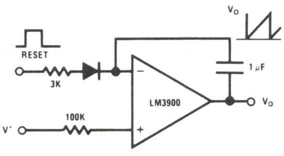


One-Shot w/ DC Input Comparator

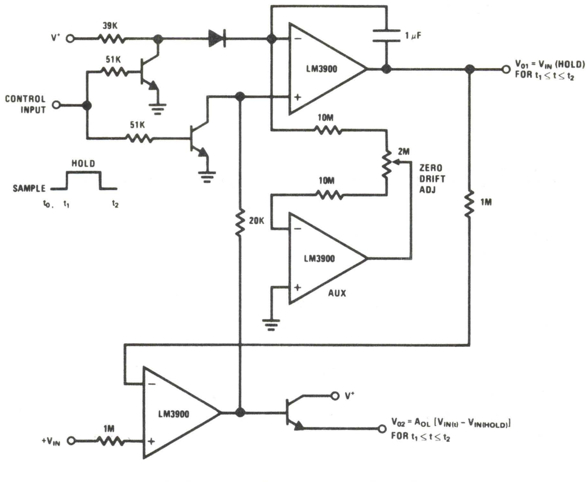
typical applications (con't)



High Pass Active Filter

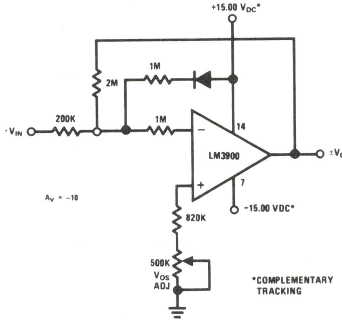


Sawtooth Generator

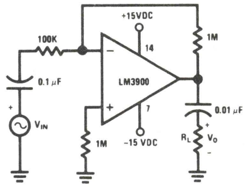


Sample-Hold & Compare with New $+V_{IN}$

split-supply applications ($V^+ = +15V_{DC}$ & $V^- = -15V_{DC}$)



Inverting DC Gain



AC Amplifier

Operational Amplifiers

LM4250/LM4250C programmable operational amplifier

general description

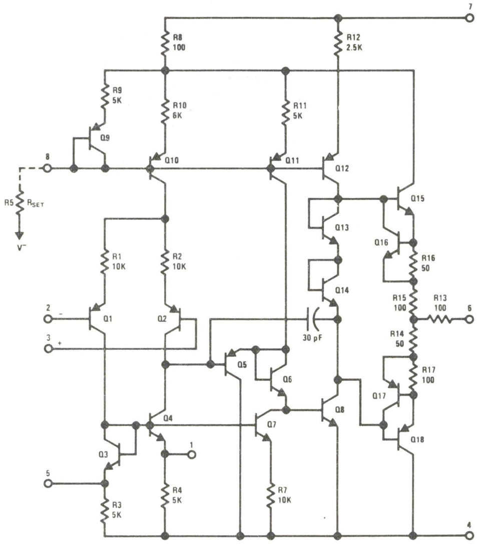
The LM4250 and LM4250C are extremely versatile programmable monolithic operational amplifiers. A single external master bias current setting resistor programs the input bias current, input offset current, quiescent power consumption, slew rate, input noise, and the gain-bandwidth product. The device is a truly general purpose operational amplifier.

features

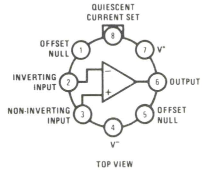
- ±1V to ±18V power supply operation
- 3 nA input offset current
- Standby power consumption as low as 500 nW
- No frequency compensation required
- Programmable electrical characteristics
- Offset Voltage nulling capability
- Can be powered by two flashlight batteries
- Short circuit protection

The LM4250C is identical to the LM4250 except that the LM4250C has its performance guaranteed over a 0°C to 70°C temperature range instead of the −55°C to +125°C temperature range of the LM4250.

schematic and connection diagrams

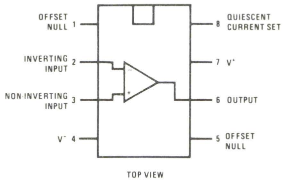


Metal Can Package



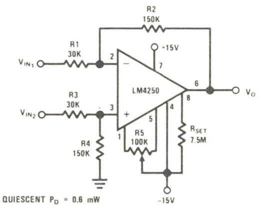
Order Number LM4250H or LM4250CH
See Package 11

Dual-In-Line Package

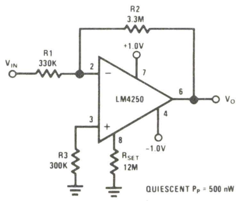


Order Number LM4250CN
See Package 20

typical applications



X5 Difference Amplifier



500 Nano-Watt X10 Amplifier

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differenital Input Voltage	±30V
Input Voltage (Note 2)	±15V
I_{SET} Current	150 μA
Output Short-Circuit Duration	Indefinite
Operating Temperature Range LM4250	$-55°C \le T_A \le 125°C$
LM4250C	$0°C \le T_A \le 70°C$
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering,10 sec)	300°C

electrical characteristics LM4250 ($-55°C \le T_A \le 125°C$ unless otherwise specified)

PARAMETERS	CONDITIONS	$V_S = \pm 1.5V$			
		$I_{SET} = 1\ \mu A$		$I_{SET} = 10\ \mu A$	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25°$ $R_S \le 100\ k\Omega$		3 mV		5 mV
I_{OS}	$T_A = 25°$		3 nA		10 nA
I_{bias}	$T_A = 25°$		7.5 nA		50 nA
Large Signal Voltage Gain	$T_A = 25°$ $R_L = 100\ k\Omega$	40k			
	$V_O = \pm 0.6$, $R_L = 10\ k\Omega$			50k	
Supply Current	$T_A = 25°C$		7.5 μA		80 μA
Power Consumption	$T_A = 25°C$		23 μW		240 μW
V_{OS}	$R_S \le 100\ k\Omega$		4 mV		6 mV
I_{OS}	$T_A = 125°C$		5 nA		10 nA
	$T_A = -55°C$		3 nA		10 nA
I_{bias}			7.5 nA		50 nA
Input Voltage Range		±0.7V		±0.7V	
Large Signal Voltage Gain	$V_O = \pm 0.6V$ $R_L = 100\ k\Omega$	30k			
	$R_L = 10\ k\Omega$			30k	
Output Voltage Swing	$R_L = 100\ k\Omega$	±0.6V			
	$R_L = 10\ k\Omega$			±0.6V	
Common Mode Rejection Ratio	$R_S \le 10\ k\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \le 10\ k\Omega$	76 dB		76 dB	
Supply Current			8 μA		90 μA
Power Consumption			24 μW		270 μW

PARAMETERS	CONDITIONS	$V_S = \pm 15V$			
		$I_{SET} = 1\ \mu A$		$I_{SET} = 10\ \mu A$	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25°C$ $R_S \le 100\ k\Omega$		3 mV		5 mV
I_{OS}	$T_A = 25°C$		3 nA		10 nA
I_{bias}	$T_A = 25°C$		7.5 nA		50 nA
Large Signal Voltage Gain	$T_A = 25°C$ $R_L = 100\ k\Omega$	100k			
	$V_O = \pm 10V$ $R_L = 10\ k\Omega$			100k	
Supply Current	$T_A = 25°C$		10 μA		90 μA
Power Consumption	$T_A = 25°C$		300 μW		2.7 mW
V_{OS}	$R_S \le 100\ k\Omega$		4 mV		6 mV
I_{OS}	$T_A = 125°C$		25 nA		25 nA
	$T_A = -55°C$		3 nA		10 nA
I_{bias}			7.5 nA		50 nA
Input Voltage Range		±13.5V		±13.5V	
Large Signal Voltage Gain	$V_O = \pm 10V$ $R_L = 100\ k\Omega$	50k			
	$R_L = 10\ k\Omega$			50k	
Output Voltage Swing	$R_L = 100\ k\Omega$	±12V			
	$R_L = 10\ k\Omega$			±12V	
Common Mode Rejection Ratio	$R_S \le 10\ k\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \le 10\ k\Omega$	76 dB		76 dB	
Supply Current			11 μA		100 μA
Power Consumption			330 μW		3 mW

Note 1: The maximum junction temperature of the LM4250 is 150°C, while that of the LM4250C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient, or 45°C/W junction to case. The thermal resistance of the dual-in-line package is 125°C/W.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

electrical characteristics LM4250C ($0°C \leq T_A \leq 70°C$ unless otherwise specified)

PARAMETERS	CONDITIONS	$V_S = \pm1.5V$			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25°C$ $R_S \leq 100\ k\Omega$		5 mV		6 mV
I_{OS}	$T_A = 25°C$		6 nA		20 nA
I_{bias}	$T_A = 25°C$		10 nA		75 nA
Large Signal Voltage Gain	$T_A = 25°C$ $R_L = 100\ k\Omega$	25k			
	$V_O = \pm0.6V$ $R_L = 10\ k\Omega$			25k	
Supply Current	$T_A = 25°C$		8 µA		90 µA
Power Consumption	$T_A = 25°C$		24 µW		270 µW
V_{OS}	$R_S \leq 10\ k\Omega$		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{bias}			10 nA		80 nA
Input Voltage Range		±0.6V		±0.6V	
Large Signal Voltage Gain	$V_O = \pm0.6V$ $R_L = 100\ k\Omega$	25k			
	$R_L = 10\ k\Omega$			25k	
Output Voltage Swing	$R_L = 100\ k\Omega$	±0.6V			
	$R_L = 10\ k\Omega$			±0.6V	
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	74 dB		74 dB	
Supply Current			8 µA		90 uA
Power Consumption			24 µW		270 uW

PARAMETERS	CONDITIONS	$V_S = \pm15V$			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25°C$ $R_S \leq 100\ k\Omega$		5 mV		6 mV
I_{OS}	$T_A = 25°C$		6 nA		20 nA
I_{bias}	$T_A = 25°C$		10 nA		75 nA
Large Signal Voltage Gain	$T_A = 25°C$ $R_L = 100\ k\Omega$	60k			
	$V_O = \pm10V$ $R_L = 10\ k\Omega$			60k	
Supply Current	$T_A = 25°C$		11 µA		100 µA
Power Consumption	$T_A = 25°C$		330 µW		3 mW
V_{OS}	$R_S \leq 10\ k\Omega$		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{bias}			10 nA		80 nA
Input Voltage Range		±13.5V		±13.5V	
Large Signal Voltage Gain	$V_O = \pm10V$ $R_L = 100\ k\Omega$	50k			
	$R_L = 10\ k\Omega$			50k	
Output Voltage Swing	$R_L = 100\ k\Omega$	±12V			
	$R_L = 10\ k\Omega$			±12V	
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	74 dB		74 dB	
Supply Current			11 uA		100 uA
Power Consumption			300 uW		3 mW

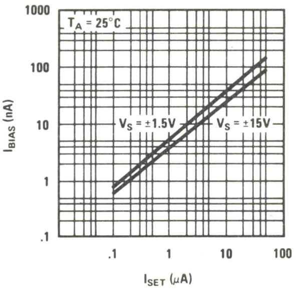
resistor biasing

Set Current Setting Resistor to V^-

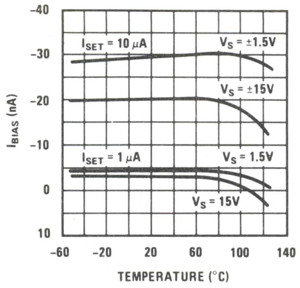
	I_{SET}				
V_S	0.1 µA	0.5 µA	1.0 µA	5 µA	10 µA
±1.5V	25.6 MΩ	5.04 MΩ	2.5 MΩ	492 kΩ	244 kΩ
±3.0V	55.6 MΩ	11.0 MΩ	5.5 MΩ	1.09 MΩ	544 kΩ
±6.0V	116 MΩ	23.0 MΩ	11.5 MΩ	2.29 MΩ	1.14 MΩ
±9.0V	176 MΩ	35.0 MΩ	17.5 MΩ	3.49 MΩ	1.74 MΩ
±12.0V	236 MΩ	47.0 MΩ	23.5 MΩ	4.69 MΩ	2.34 MΩ
±15.0V	296 MΩ	59.0 MΩ	29.5 MΩ	5.89 MΩ	2.94 MΩ

typical performance characteristics

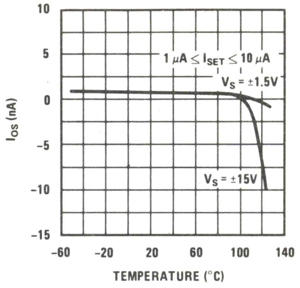
Input Bias Current vs I_{SET}



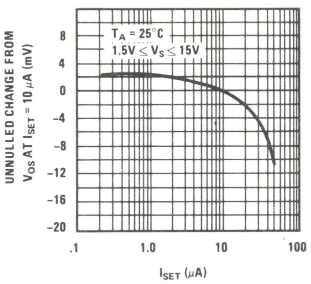
Input Bias Current vs Temperature



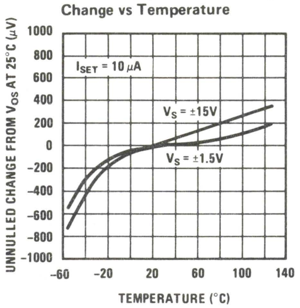
Input Offset Current vs Temperature



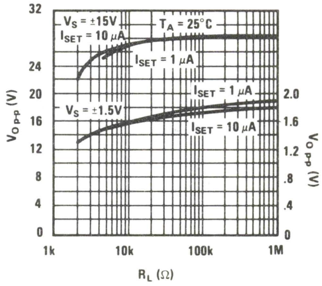
Unnulled Input Offset Voltage Change vs I_{SET}



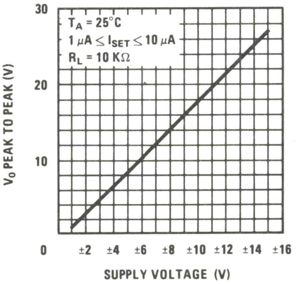
Unnulled Input Offset Voltage Change vs Temperature



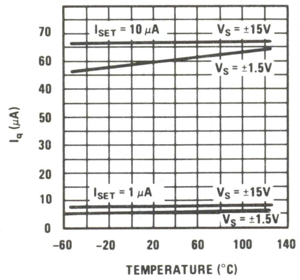
Peak to Peak Output Voltage Swing vs Load Resistance



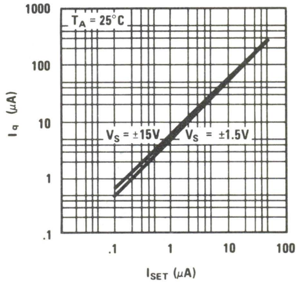
Peak to Peak Output Voltage Swing vs Supply Voltage



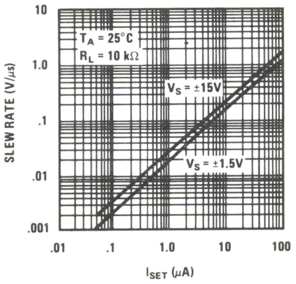
Quiescent Current (I_q) vs Temperature



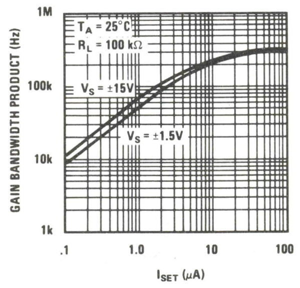
Quiescent Current (I_q) vs I_{SET}



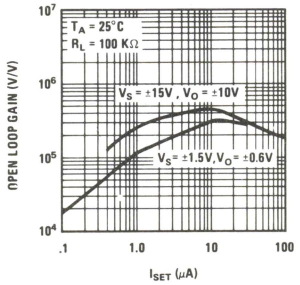
Slew Rate vs I_{SET}



Gain Bandwidth Product vs I_{SET}

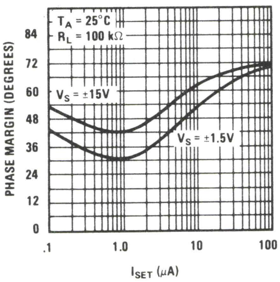


Open Loop Voltage Gain vs I_{SET}

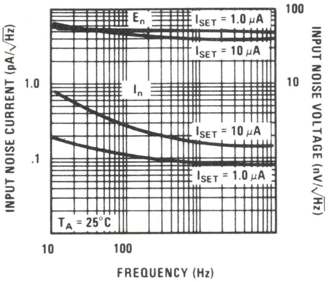


typical performance characteristics (con't)

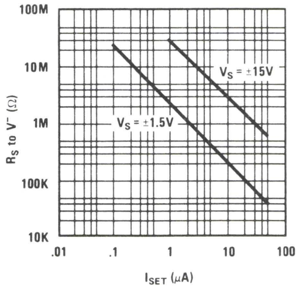
Phase Margin vs I_{SET}



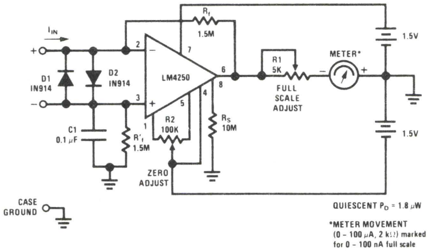
Input Noise Current (I_n) and Voltage (E_n) vs Frequency



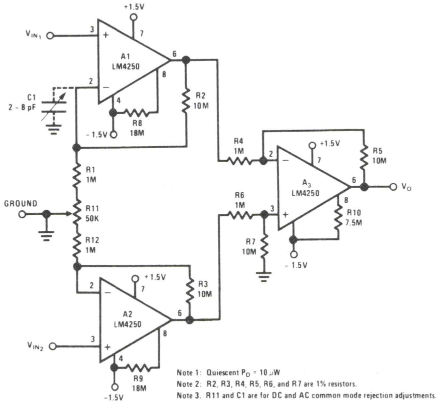
R_{SET} vs I_{SET}



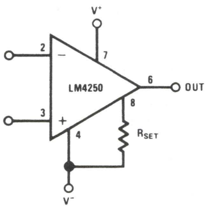
typical applications (con't)



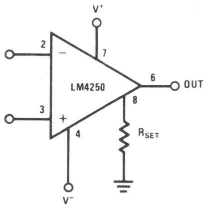
Floating Input Meter Amplifier
100 Nano-Ampere Full Scale



X100 Instrumentation Amplifier 10 μW



R_{SET} Connected to V^-

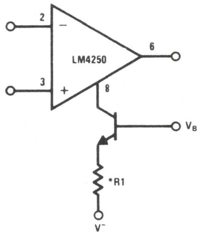


R_{SET} Connected to Ground

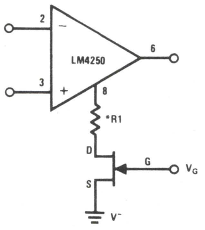
I_{SET} EQUATIONS:

$$I_{SET} \approx \frac{V^+ + |V^-| - 0.5}{R_{SET}}$$ where R_{SET} is connected to V^-.

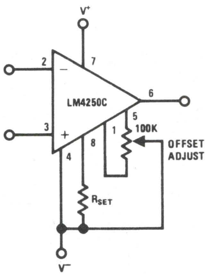
$$I_{SET} \approx \frac{V^+ - 0.5}{R_{SET}}$$ where R_{SET} is connected to ground.



Transistor Current Source Biasing



FET Current Source Biasing



Offset Null Circuit

*R1 limits I_{SET} maximum

Operational Amplifiers

LH24250/LH24250C dual programmable micropower op amp

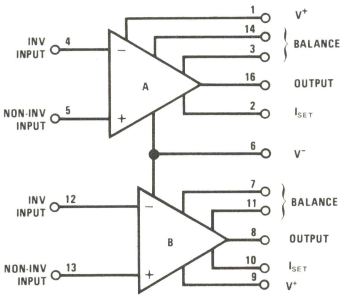
general description

The LH24250/LH24250C series of dual programmable micropower operational amplifiers are two LM4250 type op amps in a single hermetic package. Featuring all the same performance characteristics of the LM4250, the LH24250/LH24250C duals also offer closer thermal tracking, lower weight, reduced insertion cost and smaller size than two single devices. For additional information, see the LM4250 data sheet and National's Linear Application Handbook.

features

- ±1V to ±18V power supply operation
- Standby power consumption as low as 20 μW
- Offset current programmable from less than 0.5 nA to 30 nA
- Programmable slew rate
- May be shut-down using standard open collector TTL
- Internally compensated and short circuit proof

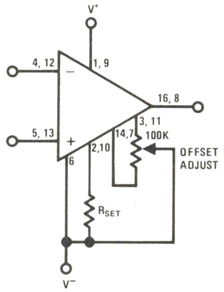
connection diagram and auxiliary circuit



Order Number LH24250F or LH24250CF
See Package 5

Order Number LH24250D or LH24250CD
See Package 2

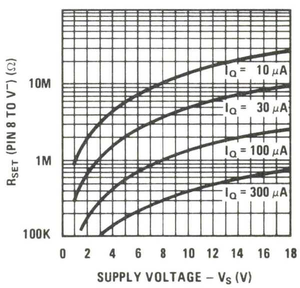
Offset Null Circuit



typical quiescent current setting resistor

(Pin 8 to V-)

V_S	10 μA	30 μA	100 μA	300 μA
±1.5	1.5 MΩ	470 kΩ	150 kΩ	
±3	3.3 MΩ	1.1 MΩ	330 kΩ	100 kΩ
±6	7.5 MΩ	2.7 MΩ	750 kΩ	220 kΩ
±9	13 MΩ	4 MΩ	1.3 MΩ	350 kΩ
±12	18 MΩ	5.6 MΩ	1.5 MΩ	510 kΩ
±15	22 MΩ	7.5 MΩ	2.2 MΩ	620 kΩ



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage (Note 2)	±15V
Input Voltage (Note 3)	±15V
Output Short Circuit Duration	Continuous
Operating Temperature Range	
LH24250	−55°C to +125°C
LH24250C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics – each side (Note 4)

PARAMETER	CONDITIONS	LIMITS		UNITS
		LH24250	LH24250C	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 100\ k\Omega$	3.0	6.0	mV Max
Input Offset Current	$T_A = 25°C$	5	10	nA Max
Input Bias Current	$T_A = 25°C$	15	30	nA Max
Input Resistance	$T_A = 25°C$	3	3	MΩ Min
Power Consumption	$T_A = 25°C$, $V_O = 0$, $R_{SET} = 2.7\ M\Omega$	480	600	μW Max
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \geq 10\ k\Omega$	100	75	V/mV Min
Input Offset Voltage	$R_S \geq 10\ k\Omega$	4.0	7.5	mV Max
Input Offset Current		5	15	nA Max
Input Bias Current		15	50	nA Max
Large Signal Voltage Gain	$R_L \geq 10\ k\Omega$	50	50	V/mV Min
Output Voltage Swing	$R_L \geq 10\ k\Omega$, $V_S = \pm 15V$	±10	±10	V Min
Input Voltage Range	$T_A = 25°C$, $V_S = \pm 15V$	±12	±12	V Min
Common Mode Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$	70	70	dB Min
Supply Voltage Rejection Ratio	$T_A = 25°C$, $R_S \leq 10\ k\Omega$	76	76	dB Min

Note 1: Derate linearly 2 mW/°C case temperature above 25°C.

Note 2: This rating applies to maximum voltage differential between input terminals. The maximum input voltage on either input terminal is limited to $\pm V_S$ up to ±15V.

Note 3: This rating limited to ± supply voltage to a maximum of ±15V.

Note 4: These specifications apply for $V_S = \pm 6V$, $I_q = 30\ \mu A$, and $-55°C \leq T_A \leq +125°C$ unless otherwise specified. With the LH24250C, however, all temperature specifications are limited to $0°C \leq T_A \leq 70°C$.

Voltage Comparators/Buffers

LM106/LM206 voltage comparator/buffer

general description

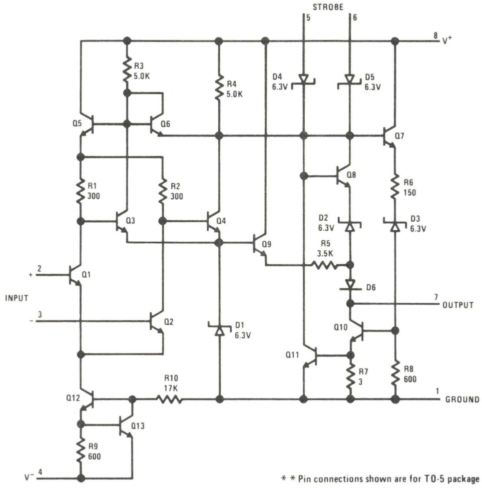
The LM106 and LM206 are high-speed voltage comparators designed to accurately detect low-level analog signals and drive a digital load. They are equivalent to an LM710, combined with a two input NAND gate and an output buffer. The circuits can drive RTL, DTL or TTL integrated circuits directly. Furthermore, their outputs can switch voltages up to 24V at currents as high as 100 mA. Other features include:

- Improved accuracy: 2 mV maximum worst case offset.
- Fan-out of 10 with DTL or TTL
- Added logic or strobe capability
- Useful as a relay or lamp driver
- Plug-in replacement for the LM710.
- 40 ns maximum response time

The devices have short-circuit protection which limits the inrush current when it is used to drive incandescent lamps, in addition to preventing damage from accidental shorts to the positive supply. The speed is equivalent to that of an LM710. However, they are even faster where buffers and additional logic circuitry can be eliminated by the increased flexibility of the LM106 and LM206. They can also be operated from any negative supply voltage between −3V and −12V with little effect on performance.

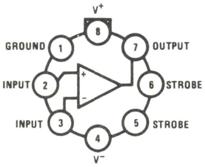
The LM106 is specified for operation over the −55°C to +125°C military temperature range. The LM206 is specified for operation over the −25°C to +85°C temperature range.

schematic and connection diagrams **



** Pin connections shown are for TO-5 package

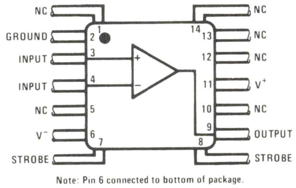
Metal Can



Note: Pin 4 connected to case.

Order Number LM106H or LM206H
See Package 11

Flat Package



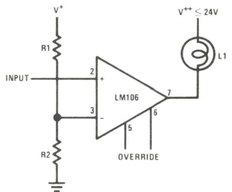
Note: Pin 6 connected to bottom of package.

TOP VIEW

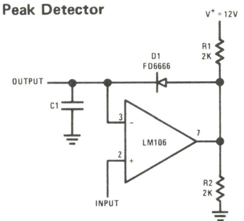
Order Number LM106F or LM206F
See Package 4

typical applications **

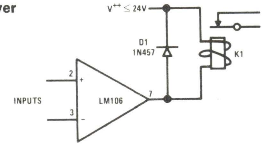
Level Detector and Lamp Driver



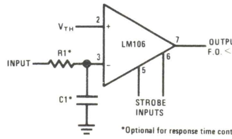
Fast Response Peak Detector



Relay Driver



Adjustable Threshold Line Receiver



*Optional for response time control.

absolute maximum ratings

Positive Supply Voltage	15V
Negative Supply Voltage	−15V
Output Voltage	24V
Output to Negative Supply Voltage	30V
Differential Input Voltage	±5V
Input Voltage	±7V
Power Dissipation (Note 1)	600 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range LM106	−55°C to 125°C
LM206	−25°C to 85°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3		0.5	2.0	mV
Input Offset Current	Note 3		0.7	3.0	μA
Input Bias Current			10	20	μA
Response Time	Note 4, R_L = 390Ω to +5V, C_L = 15 pF		28	40	ns
Saturation Voltage	$V_{IN} \leq -5$ mV, I_{OUT} = 100 mA		1.0	1.5	V
Output Leakage Current	$V_{IN} \geq 5$ mV, $8V \leq V_{OUT} \leq 24V$		0.02	1.0	μA

electrical characteristics

The following specifications apply for $T_L \leq T_A \leq T_H$ (Note 5)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	10	μV/°C
Input Offset Current	Note 3, $T_L \leq T_A \leq 25°C$		1.8	7.0	μA
	$25°C \leq T_A \leq T_H$		0.25	3.0	μA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq T_H$		5.0	25	nA/°C
	$T_L \leq T_A \leq 25°C$		15	75	nA/°C
Input Bias Current	$T_L \leq T_A \leq 25°C$			45	μA
	$25°C \leq T_A \leq T_H$			20	μA
Input Voltage Range	$-7V \geq V^- \geq -12V$	±5.0			V
Differential Input Voltage Range		±5.0			V
Saturation Voltage	$V_{IN} \leq -5$ mV, I_{OUT} = 50 mA			1.0	V
Saturation Voltage	$V_{IN} \leq -5$ mV, I_{OUT} = 16 mA			0.4	V
Positive Output Level	$V_{IN} \geq 5$ mV, I_{OUT} = −400 μA	2.5		5.5	V
Output Leakage Current	$V_{IN} \geq 5$ mV, $8V \leq V_{OUT} \leq 24V$, $T_L \leq T_A \leq 25°C$			1.0	μA
	$25°C < T_A \leq T_H$			100	μA
Strobe Current	V_{strobe} = 0.4V		−1.7	−3.2	mA
Strobe ON Voltage		0.9	1.4		V
Strobe OFF Voltage	$I_{sink} \leq 16$ mA		1.4	2.2	V
Positive Supply Current	V_{IN} = −5 mV		5.5	10	mA
Negative Supply Current			−1.5	−3.6	mA

Note 1: The maximum junction temperature of the LM106 is 150°C, while that of the LM206 is 110°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.

Note 2: These specifications apply for $-3V \geq V^- \geq -12V$, V^+ = 12V and T_A = 25°C unless otherwise specified. All currents into device pins are considered positive.

Note 3: The offset voltages and offset currents given are the maximum values required to drive the output down to 0.5V or up to 5.0V. Thus, these parameters actually define an error band and take into account the worst-case effects of voltage gain, specified supply voltage variations, and common mode voltage variations.

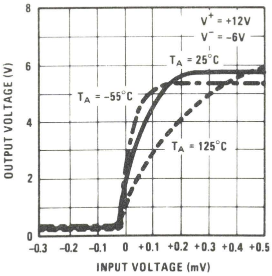
Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

Note 5: All currents into device pins are considered positive.

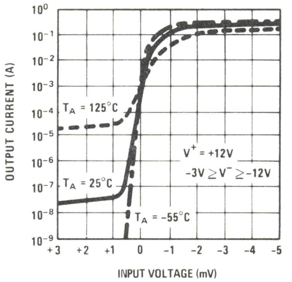
	T_L	T_H
LM106	−55°C	+125°C
LM206	−25°C	+85°C

typical performance characteristics

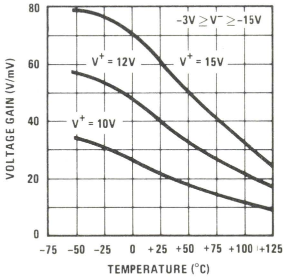
Transfer Function



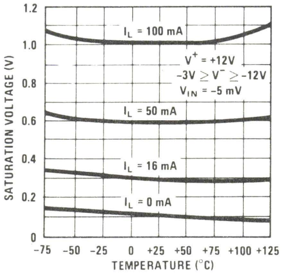
Transconductance



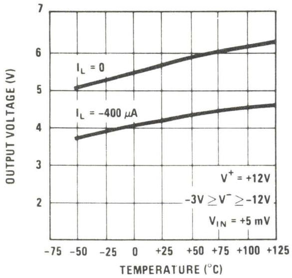
Voltage Gain



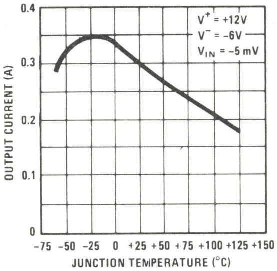
Saturation Voltage



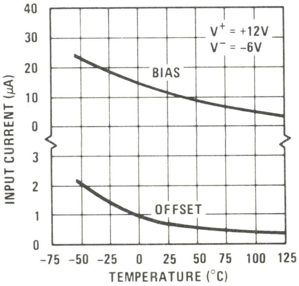
Positive Output Level



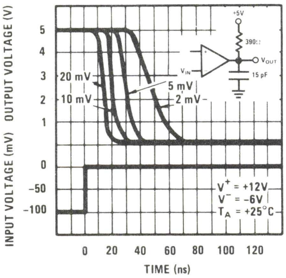
Short Circuit Output Current



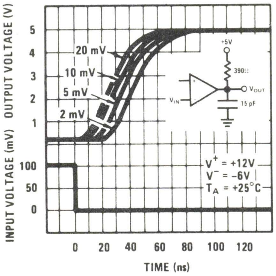
Input Current



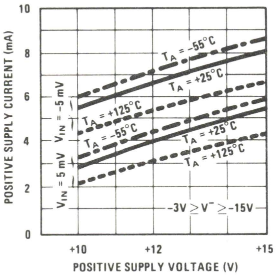
Response Time For Various Input Overdrives



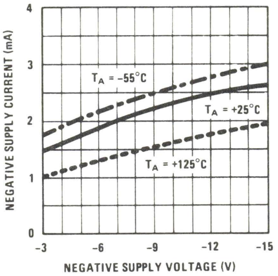
Response Time For Various Input Overdrives



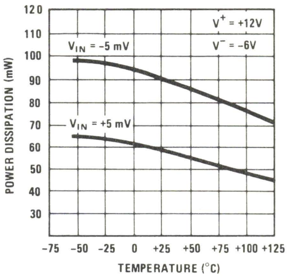
Positive Supply Current



Negative Supply Current



Power Consumption



3

Voltage Comparators/Buffers

LM306 voltage comparator/buffer

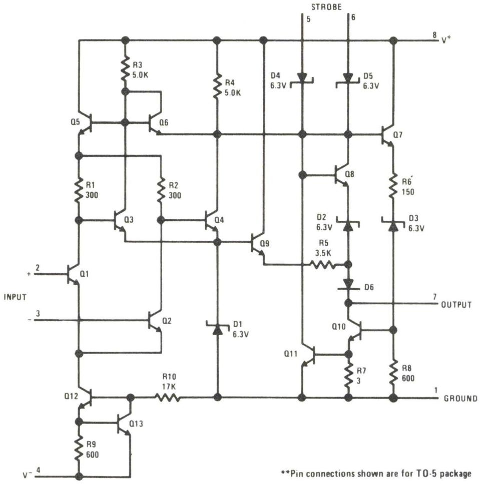
general description

The LM306 is a high-speed voltage comparator designed to accurately detect low-level analog signals and drive a digital load. It is equivalent to an LM710C, combined with a two input NAND gate and an output buffer. The circuit can drive RTL, DTL or TTL integrated circuits directly. Furthermore, the output can switch voltages up to 24V at currents as high as 100 mA. Other features include:

- Improved accuracy: 5 mV (max) offset
- Fan-out of 10 with DTL or TTL
- Added logic or strobe capability
- Useful as a relay or lamp driver
- Plug-in replacement for the LM710C.
- 40 ns maximum response time

The device has short-circuit protection which limits the inrush current when it is used to drive incandescent lamps, in addition to preventing damage from accidental shorts. The speed is equivalent to that of an LM710C. However, it is even faster where buffers and additional logic circuitry can be eliminated by the increased flexibility of the LM306. It can also be operated from any negative supply voltage between −3V and −12V with little effect on performance. The LM306 is identical to the LM106, except that it is specified over a 0°C to 70°C temperature range.

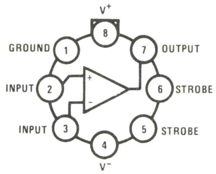
schematic and connection diagrams**



**Pin connections shown are for TO-5 package

Metal Can

TOP VIEW



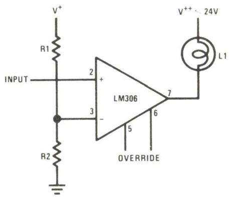
Note: Pin 4 connected to case.

Order Number LM306H

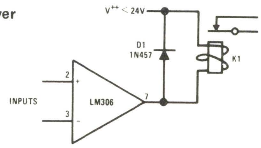
See Package 11

typical applications**

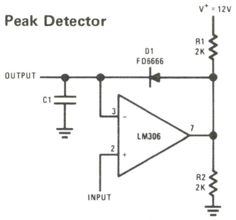
Level Detector and Lamp Driver



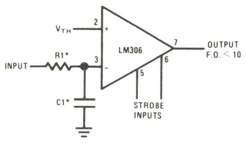
Relay Driver



Fast Response Peak Detector



Adjustable Threshold Line Receiver



*Optional for response time control.

absolute maximum ratings

Positive Supply Voltage	15V
Negative Supply Voltage	−15V
Output Voltage	24V
Output to Negative Supply Voltage	30V
Differential Input Voltage	±5V
Input Voltage	±7V
Power Dissipation (Note 1)	600 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3		1.6	5.0	mV
Input Offset Current	Note 3		1.8	5.0	μA
Input Bias Current			16	25	μA
Response Time	Note 4, R_L = 390Ω to +5V, C_L = 15 pF		28	40	ns
Saturation Voltage	$V_{IN} \le -7$ mV, I_{OUT} = 100 mA		0.8	2.0	V
Output Leakage Current	$V_{IN} \ge 7$ mV, $8V \le V_{OUT} \le 24V$		0.02	2.0	μA

electrical characteristics

The following specifications apply for $0°C \le T_A \le 70°C$ (Note 5)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3			6.5	mV
Average Temperature Coefficient of Input Offset Voltage			5	20	μV/°C
Input Offset Current	Note 3, $0°C \le T_A < 25°C$		2.4	7.5	μA
	$25°C \le T_A \le 70°C$			5.0	μA
Average Temperature Coefficient of Input Offset Current	$25°C \le T_A \le 70°C$		15	50	nA/°C
	$0°C \le T_A \le 25°C$		24	100	nA/°C
Input Bias Current	$0°C \le T_A < 25°C$		25	40	μA
	$25°C \le T_A \le 70°C$			25	μA
Input Voltage Range	$-7V \ge V^- \ge -12V$	±5.0			V
Differential Input Voltage Range		±5.0			V
Saturation Voltage	$V_{IN} \le -8$ mV, I_{OUT} = 50 mA			1.0	V
Saturation Voltage	$V_{IN} \le -8$ mV, I_{OUT} = 16 mA			0.4	V
Positive Output Level	$V_{IN} \ge 8$ mV, I_{OUT} = −400 μA	2.5		5.5	V
Output Leakage Current	$V_{IN} \ge 8$ mV, $8V \le V_{OUT} \le 24V$				
	$0°C \le T_A \le 25°C$			2.0	μA
	$25°C < T_A \le 70°C$			100	μA
Strobe Current	V_{strobe} = 0.4V		−1.7	−3.2	mA
Strobe ON Voltage		0.9	1.4		V
Strobe OFF Voltage	$I_{sink} \le 16$ mA		1.4	2.2	V
Positive Supply Current	V_{IN} = −8 mV		5.5	10	mA
Negative Supply Current			−1.5	−3.6	mA

Note 1: For operating at elevated temperatures, the device must be derated based on a 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient.

Note 2: These specifications apply for $-3V \ge V^- \ge -12V$, V^+ = 12V and T_A = 25°C unless otherwise specified. All currents into pins are considered positive.

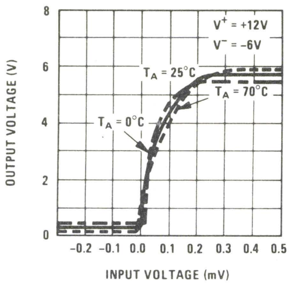
Note 3: The offset voltages and offset currents given are the maximum values required to drive the output down to 0.5V or up to 5.0V. Thus, these parameters actually define an error band and take into account the worst-case effects of voltage gain, and input impedance, specified supply voltage variations, and common mode voltage variations.

Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

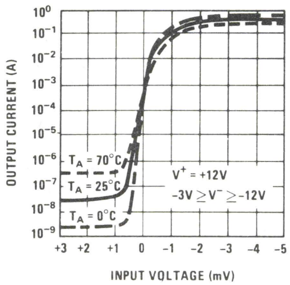
Note 5: All currents into device pins are considered positive.

typical performance characteristics

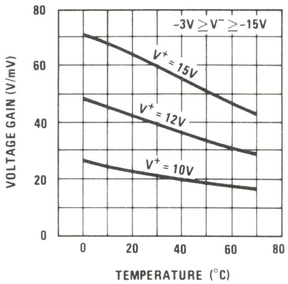
Transfer Function



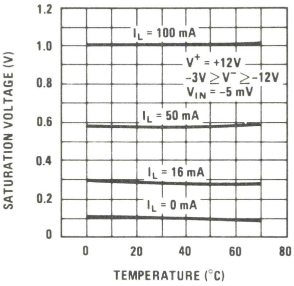
Transconductance



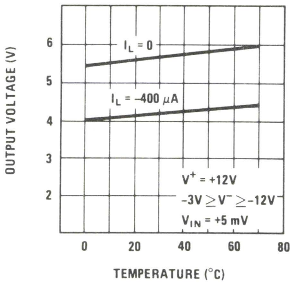
Voltage Gain



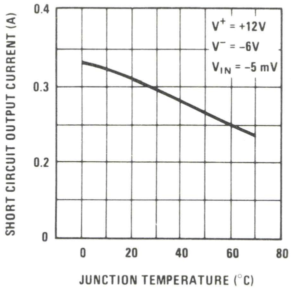
Saturation Voltage



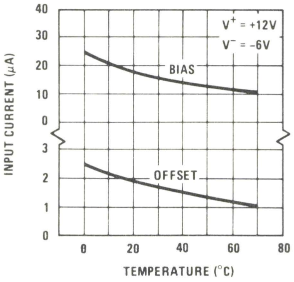
Positive Output Level



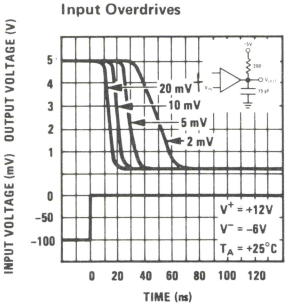
Short Circuit Output Current



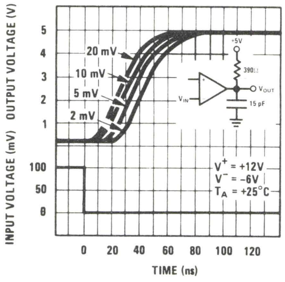
Input Current



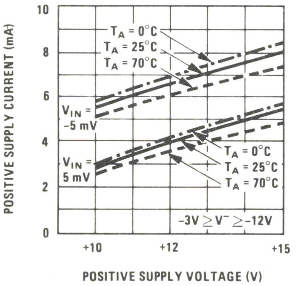
Response Time for Various Input Overdrives



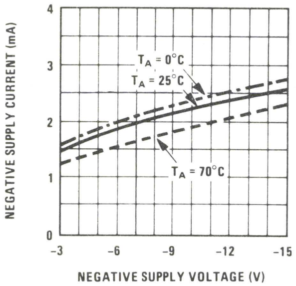
Response Time for Various Input Overdrives



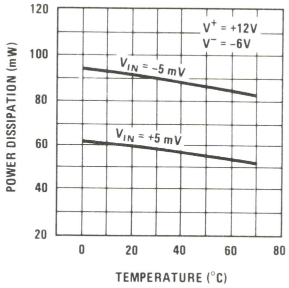
Positive Supply Current



Negative Supply Current



Power Dissipation



Voltage Comparators/Buffers

LM111/LM211 voltage comparator

general description

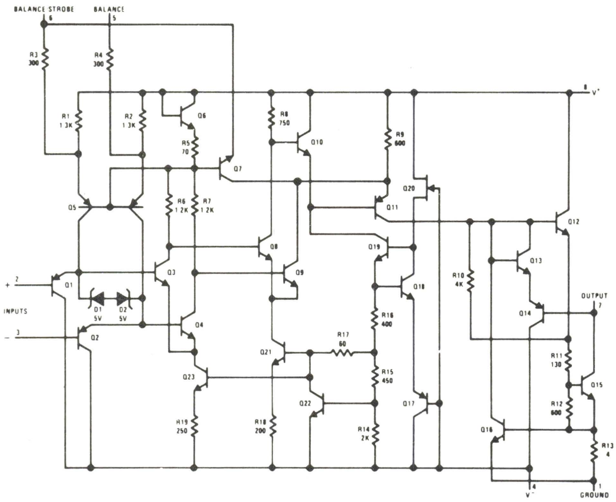
The LM111 and LM211 are voltage comparators that have input currents nearly a thousand times lower than devices like the LM106 or LM710. They are also designed to operate over a wider range of supply voltages: from standard ±15V op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50V at currents as high as 50 mA. Outstanding characteristics include:

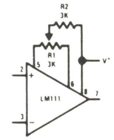
- Operates from single 5V supply
- Input current: 150 nA max. over temperature
- Offset current: 20 nA max. over temperature
- Differential input voltage range: ±30V
- Power consumption: 135 mW at ±15V

Both the inputs and the outputs of the LM111 or the LM211 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM106 and LM710 (200 ns response time vs 40 ns) the devices are also much less prone to spurious oscillations. The LM111 has the same pin configuration as the LM106 and LM710.

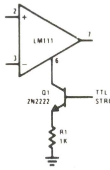
The LM211 is identical to the LM111, except that its performance is specified over a −25°C to 85°C temperature range instead of −55°C to 125°C.

schematic diagram and auxiliary circuits**

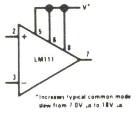




Offset Balancing



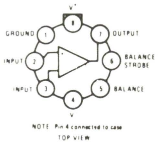
Strobing



Increasing Input Stage Current*

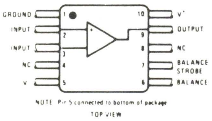
connection diagrams**

Metal Can



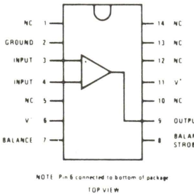
Order Number LM111H or LM211H
See Package 11

Flat Package



Order Number LM111F or LM211F
See Package 3

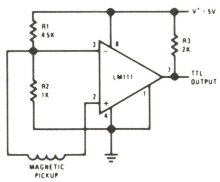
Dual-In-Line



Order Number LM111D or LM211D
See Package 1

**Pin connections shown are for metal can.

typical application



Detector for Magnetic Transducer

absolute maximum ratings

Total Supply Voltage (V_{84})		36V
Output to Negative Supply Voltage (V_{74})		50V
Ground to Negative Supply Voltage (V_{14})		30V
Differential Input Voltage		±30V
Input Voltage (Note 1)		±15V
Power Dissipation (Note 2)		500 mW
Output Short Circuit Duration		10 sec
Operating Temperature Range	LM111	−55°C to 125°C
	LM211	−25°C to 85°C
Storage Temperature Range		−65°C to 150°C
Lead Temperature (soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	T_A = 25°C, $R_S \leq$ 50k		0.7	3.0	mV
Input Offset Current (Note 4)	T_A = 25°C		4.0	10	nA
Input Bias Current	T_A = 25°C		60	100	nA
Voltage Gain	T_A = 25°C		200		V/mV
Response Time (Note 5)	T_A = 25°C		200		ns
Saturation Voltage	$V_{IN} \leq$ −5 mV, I_{OUT} = 50 mA T_A = 25°C		0.75	1.5	V
Strobe On Current	T_A = 25°C		3.0		mA
Output Leakage Current	$V_{IN} \geq$ 5 mV, V_{OUT} = 35V T_A = 25°C		0.2	10	nA
Input Offset Voltage (Note 4)	$R_S \leq$ 50k			4.0	mV
Input Offset Current (Note 4)				20	nA
Input Bias Current				150	nA
Input Voltage Range			±14		V
Saturation Voltage	$V^+ \geq$ 4.5V, V^- = 0 $V_{IN} \leq$ −6 mV, $I_{SINK} \leq$ 8 mA		0.23	0.4	V
Output Leakage Current	$V_{IN} \geq$ 5 mV, V_{OUT} = 35V		0.1	0.5	μA
Positive Supply Current	T_A = 25°C		5.1	6.0	mA
Negative Supply Current	T_A = 25°C		4.1	5.0	mA

Note 1: This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 2: The maximum junction temperature of the LM111 is 150°C, while that of the LM211 is 110°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

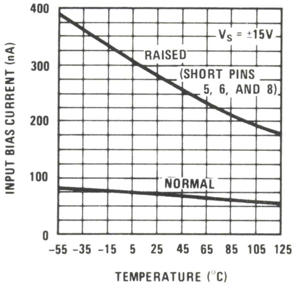
Note 3: These specifications apply for V_S = ±15V and −55°C $\leq T_A \leq$ 125°C, unless otherwise stated. With the LM211, however, all temperature specifications are limited to −25°C $\leq T_A \leq$ 85°C. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

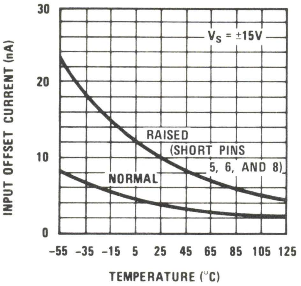
Note 5: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics

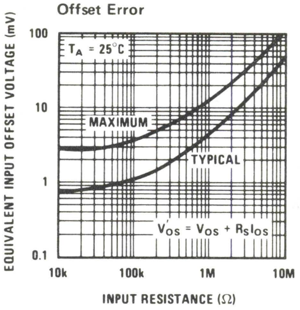
Input Bias Current



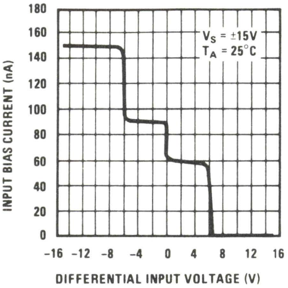
Input Offset Current



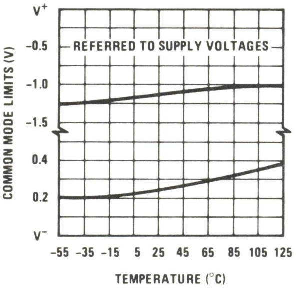
Offset Error



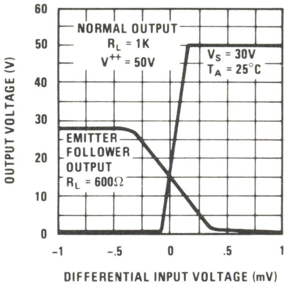
Input Characteristics



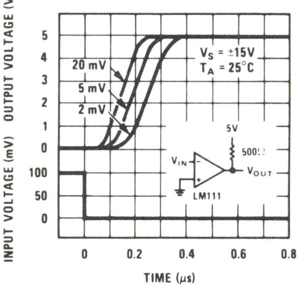
Common Mode Limits



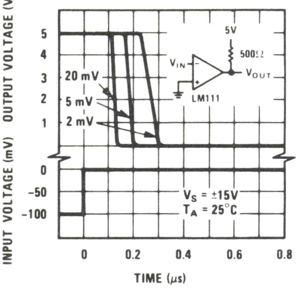
Transfer Function



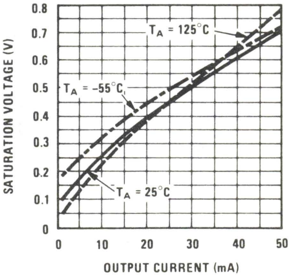
Response Time for Various Input Overdrives



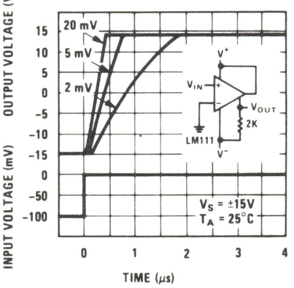
Response Time for Various Input Overdrives



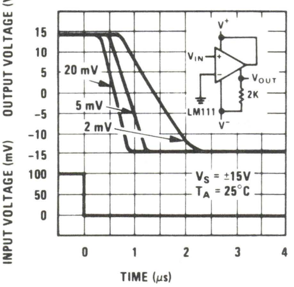
Output Saturation Voltage



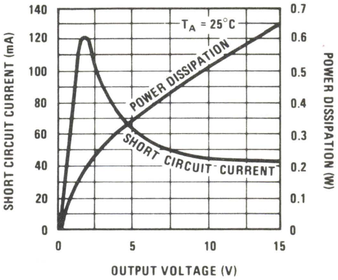
Response Time for Various Input Overdrives



Response Time for Various Input Overdrives



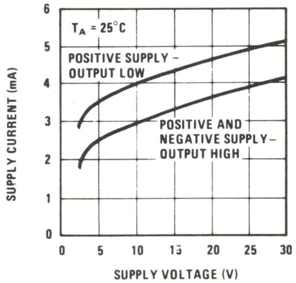
Output Limiting Characteristics



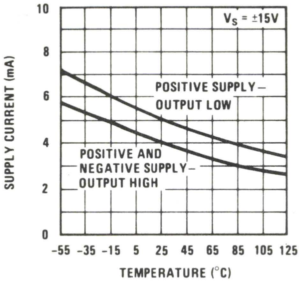
3

typical performance characteristics (con't)

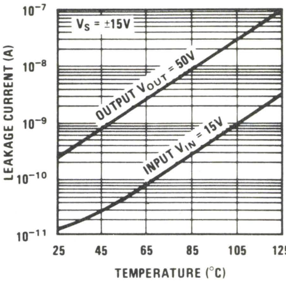
Supply Current



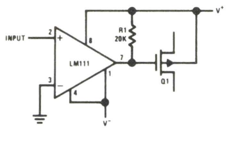
Supply Current



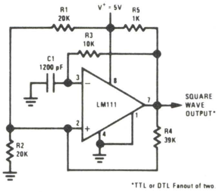
Leakage Currents



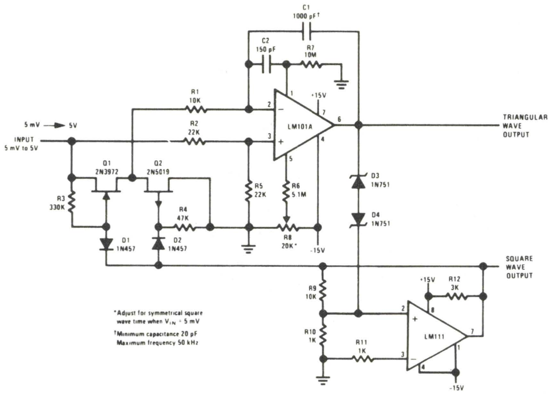
typical applications (con't)



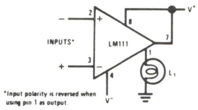
Zero Crossing Detector Driving MOS Switch



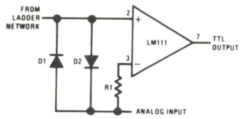
100 kHz Free Running Multivibrator



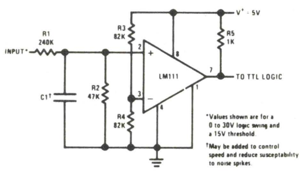
10 Hz to 10 kHz Voltage Controlled Oscillator



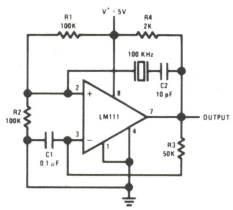
Driving Ground-Referred Load



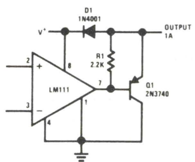
Using Clamp Diodes to Improve Response



TTL Interface with High Level Logic

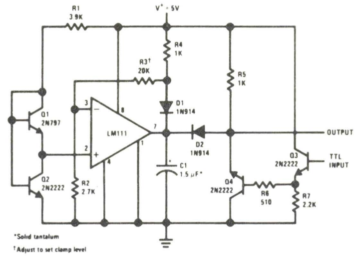


Crystal Oscillator

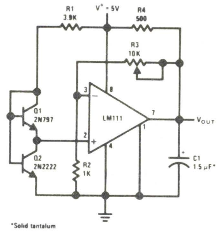


Comparator and Solenoid Driver

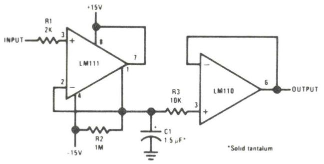
typical applications (con't)



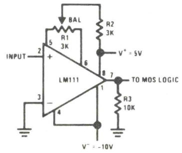
Precision Squarer



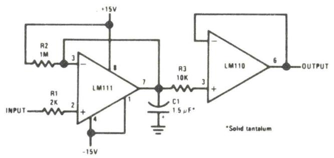
Low Voltage Adjustable Reference Supply



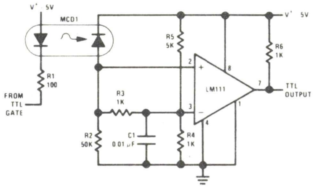
Positive Peak Detector



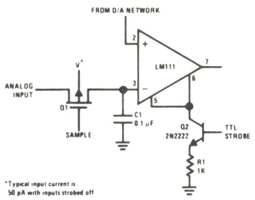
Zero Crossing Detector driving MOS logic



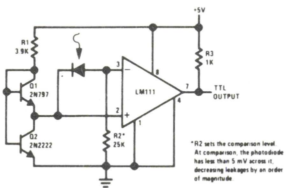
Negative Peak Dectector



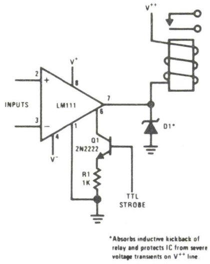
Digital Transmission Isolator



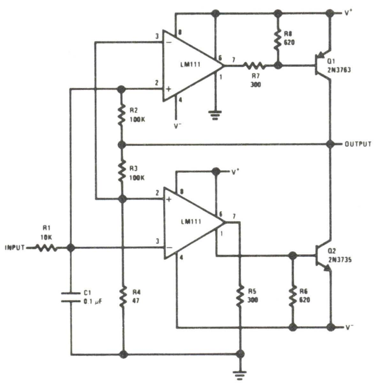
Strobing off Both Input* and Output Stages



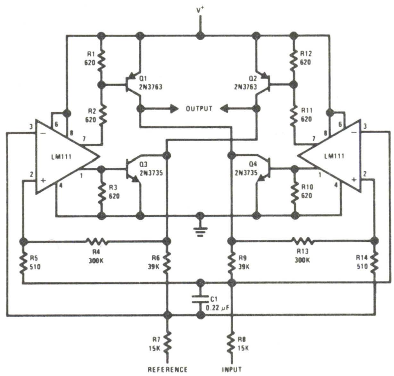
Precision Photodiode Comparator



Relay Driver with Strobe



Switching Power Amplifier



Switching Power Amplifier

Voltage Comparators/Buffers

LM311 voltage comparator

general description

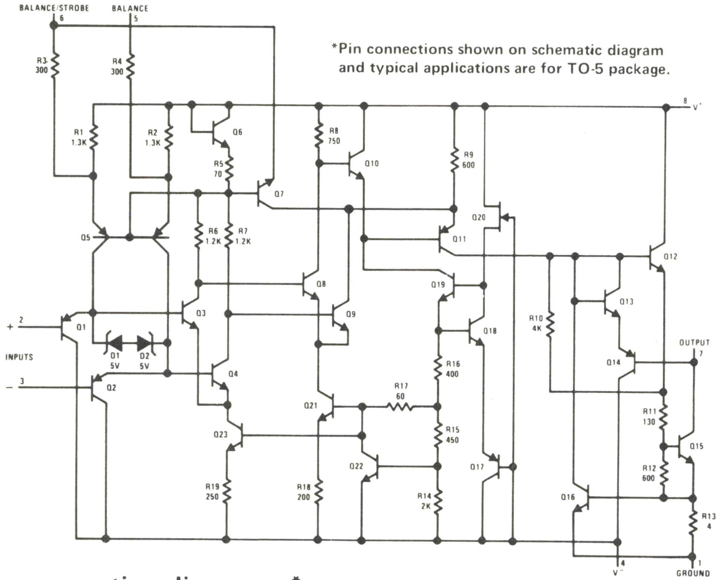
The LM311 is a voltage comparator that has input currents more than a hundred times lower than devices like the LM306 or LM710C. It is also designed to operate over a wider range of supply voltages: from standard ±15V op amp supplies down to the single 5V supply used for IC logic. Its output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, it can drive lamps or relays, switching voltages up to 40V at currents as high as 50 mA.

features

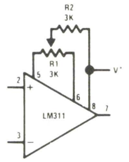
- Operates from single 5V supply
- Maximum input current: 250 nA
- Maximum offset current: 50 nA
- Differential input voltage range: ±30V
- Power consumption: 135 mW at ±15V

Both the input and the output of the LM311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM306 and LM710C (200 ns response time vs 40 ns) the device is also much less prone to spurious oscillations. The LM311 has the same pin configuration as the LM306 and LM710C.

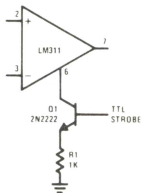
schematic diagram and auxiliary circuits



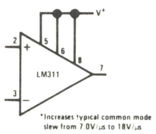
*Pin connections shown on schematic diagram and typical applications are for TO-5 package.



Offset Balancing



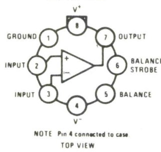
Strobing



Increasing Input Stage Current*

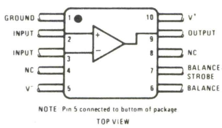
connection diagrams *

Metal Can



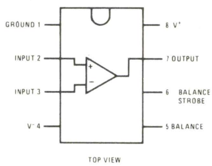
Order Number LM311H
See Package 11

Flat Package



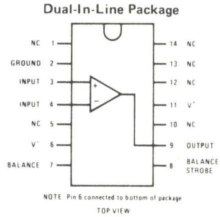
Order Number LM311F
See Package 3

Dual-In-Line Package



Order Number LM311N
See Package 20

Dual-In-Line Package



Order Number LM311D
See Package 1 or
Order Number LM311N-14
See Package 22

absolute maximum ratings

Total Supply Voltage (V_{84})	36V
Output to Negative Supply Voltage (V_{74})	40V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	±30V
Input Voltage (Note 1)	±15V
Power Dissipation (Note 2)	500 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25°C$, $R_S \le 50K$		2.0	7.5	mV
Input Offset Current (Note 4)	$T_A = 25°C$		6.0	50	nA
Input Bias Current	$T_A = 25°C$		100	250	nA
Voltage Gain	$T_A = 25°C$		200		V/mV
Response Time (Note 5)	$T_A = 25°C$		200		ns
Saturation Voltage	$V_{IN} \le -10$ mV, $I_{OUT} = 50$ mA $T_A = 25°C$		0.75	1.5	V
Strobe On Current	$T_A = 25°C$		3.0		mA
Output Leakage Current	$V_{IN} \ge 10$ mV, $V_{OUT} = 35V$ $T_A = 25°C$		0.2	50	nA
Input Offset Voltage (Note 4)	$R_S \le 50K$			10	mV
Input Offset Current (Note 4)				70	nA
Input Bias Current				300	nA
Input Voltage Range			±14		V
Saturation Voltage	$V^+ \ge 4.5V$, $V^- = 0$ $V_{IN} \le -10$ mV, $I_{SINK} \le 8$ mA		0.23	0.4	V
Positive Supply Current	$T_A = 25°C$		5.1	7.5	mA
Negative Supply Current	$T_A = 25°C$		4.1	5.0	mA

Note 1: This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 2: The maximum junction temperature of the LM311 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15V$ and $0°C < T_A < 70°C$, unless otherwise specified. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

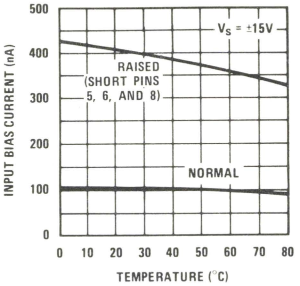
Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

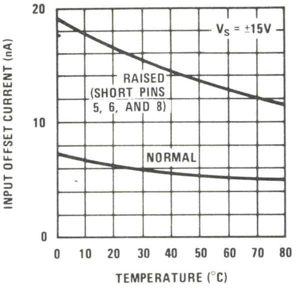
3

typical performance characteristics

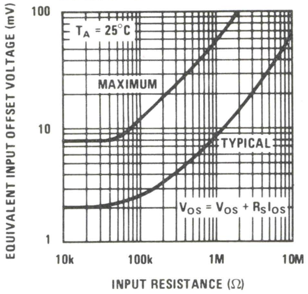
Input Bias Current



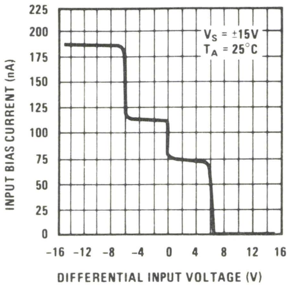
Input Offset Current



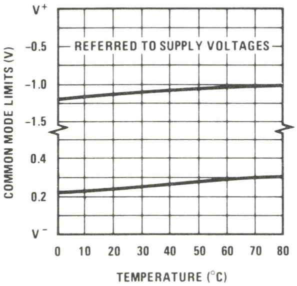
Offset Error



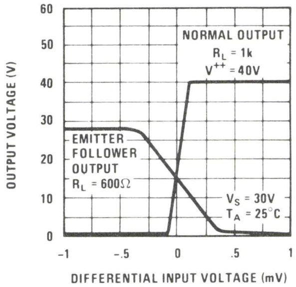
Input Characteristics



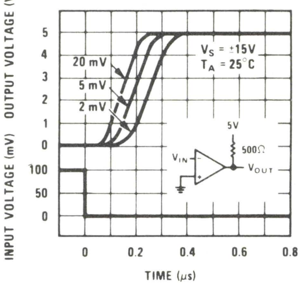
Common Mode Limits



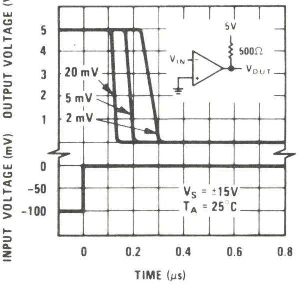
Transfer Function



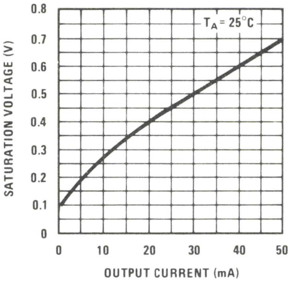
Response Time for Various Input Overdrives



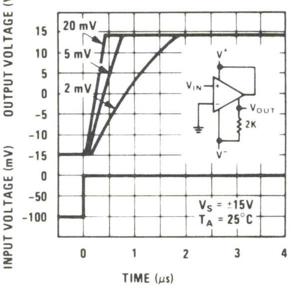
Response Time for Various Input Overdrives



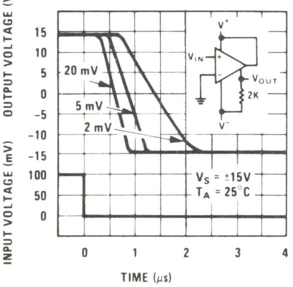
Output Saturation Voltage



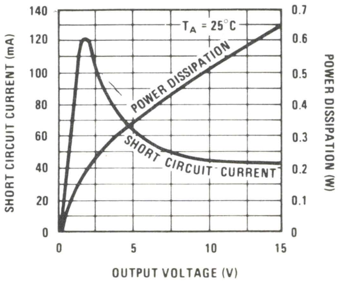
Response Time for Various Input Overdrives



Response Time for Various Input Overdrives

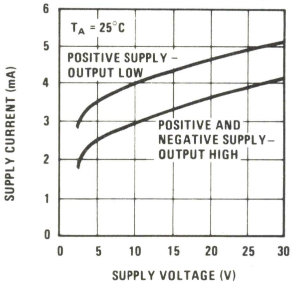


Output Limiting Characteristics

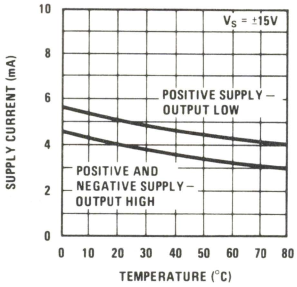


typical performance characteristics (con't)

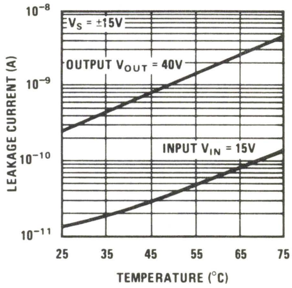
Supply Current



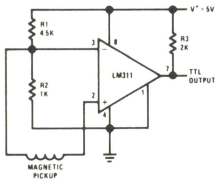
Supply Current



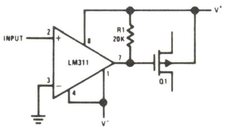
Leakage Currents



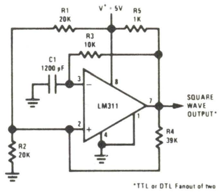
typical applications



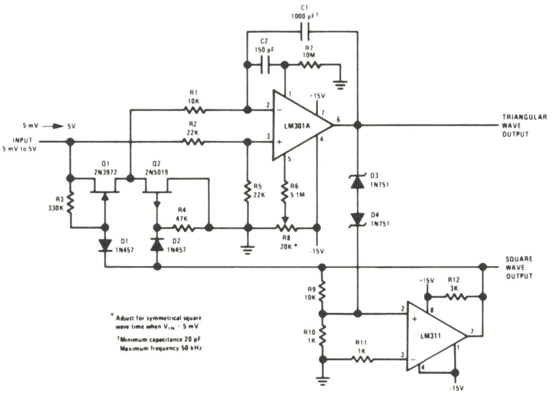
Detector for Magnetic Transducer



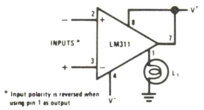
Zero Crossing Detector Driving MOS Switch



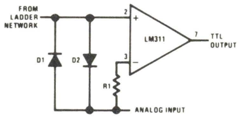
100 kHz Free Running Multivibrator



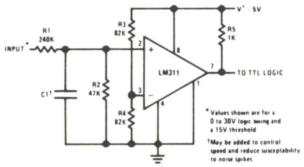
10 Hz to 10 kHz Voltage Controlled Oscillator



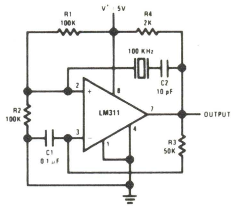
Driving Ground-Referred Load



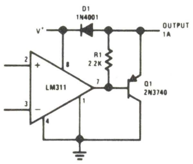
Using Clamp Diodes to Improve Response



TTL Interface with High Level Logic

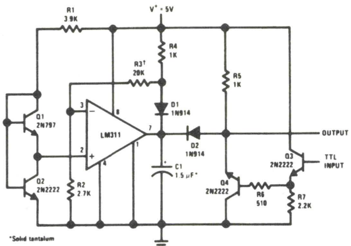


Crystal Oscillator



Comparator and Solenoid Driver

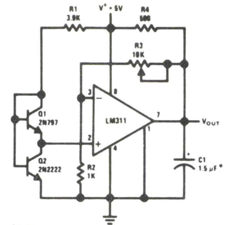
typical applications (con't)



*Solid tantalum

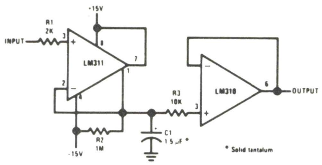
†Adjust to set clamp level

Precision Squarer



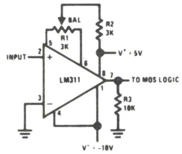
* Solid tantalum

Low Voltage Adjustable Reference Supply

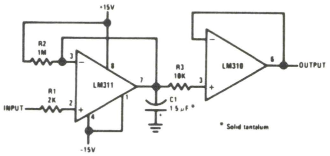


* Solid tantalum

Positive Peak Detector

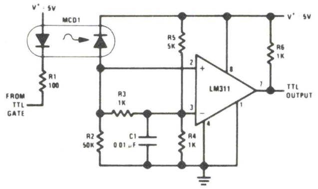


Zero Crossing Detector driving MOS logic

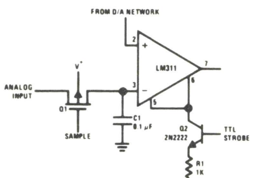


* Solid tantalum

Negative Peak Dectector

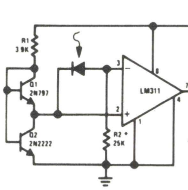


Digital Transmission Isolator



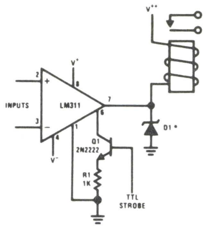
*Typical input current is 50 pA with inputs strobed off

Strobing off Both Input*
and Output Stages



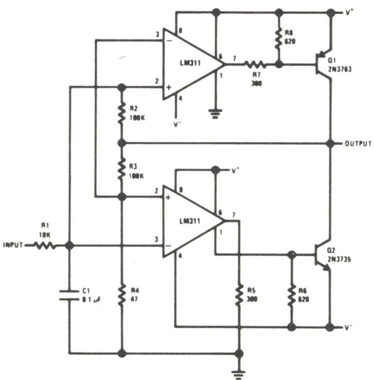
* R2 sets the comparison level. At comparison, the photodiode has less than 5 mV across it, decreasing leakages by an order of magnitude

Precision Photodiode Comparator

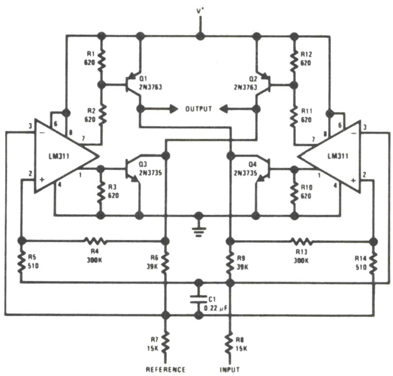


* Absorbs inductive kickback of relay and protects IC from severe voltage transients on V⁺⁺ line

Relay Driver with Strobe



Switching Power Amplifier



Switching Power Amplifier

Voltage Comparators/Buffers

LM119/LM219 high speed dual comparator

general description

The LM119/LM219 are precision high speed dual comparators fabricated on a single monolithic chip. They are designed to operate over a wide range of supply voltages down to a single 5V logic supply and ground. Further, they have higher gain and lower input currents than devices like the LM710. The uncommitted collector of the output stage makes the LM119 compatible with RTL, DTL and TTL as well as capable of driving lamps and relays at currents up to 25 mA. Outstanding features include:

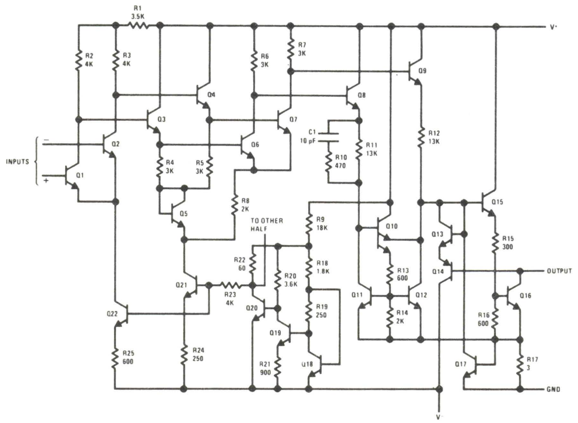
features

- Two independent comparators
- Operates from a single 5V supply
- Typically 80 ns response time at ±15V
- Minimum fan-out of 2 each side
- Maximum input current of 1 μA over temperature
- Inputs and outputs can be isolated from system ground
- High common mode slew rate

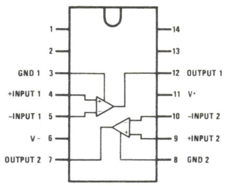
Although designed primarily for applications requiring operation from digital logic supplies, the LM119 is fully specified for power supplies up to ±15V. It features faster response than the LM111 at the expense of higher power dissipation. However, the high speed, wide operating voltage range and low package count make the LM119 much more versatile than older devices like the LM711.

The LM219 is identical to the LM119, except that its performance is specified over a −25°C to 85°C temperature range instead of −55°C to 125°C.

schematic and connection diagrams



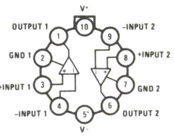
Dual-In-Line-Package



TOP VIEW

Order Number LM119D or LM219D
See Package 1

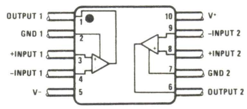
Metal Can Package



TOP VIEW

Order Number LM119H or LM219H
See Package 12

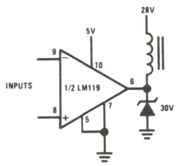
Flat Package



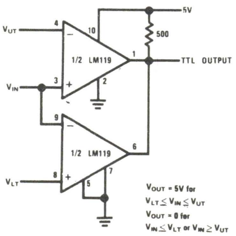
TOP VIEW

Order Number LM119F or LM219F
See Package 3

typical applications



Relay Driver



Window Detector

absolute maximum ratings

Total Supply Voltage	36V	Power Dissipation (Note 2)	500 mW
Output to Negative Supply Voltage	36V	Output Short Circuit Duration	10 sec
Ground to Negative Supply Voltage	25V	Operating Temperature Range LM119	−55°C to 125°C
Ground to Positive Supply Voltage	18V	LM219	−25°C to 85°C
Differential Input Voltage	±5V	Storage Temperature Range	−65°C to 150°C
Input Voltage (Note 1)	±15V	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	T_A = 25°C, $R_S \leq$ 5k		0.7	4.0	mV
Input Offset Current (Note 4)	T_A = 25°C		30	75	nA
Input Bias Current	T_A = 25°C		150	500	nA
Voltage Gain	T_A = 25°C	10	40		V/mV
Response Time (Note 5)	T_A = 25°C V_S = ±15V		80		ns
Saturation Voltage	$V_{IN} \leq$ −5 mV, I_{OUT} = 25 mA T_A = 25°C		0.75	1.5	V
Output Leakage Current	$V_{IN} \geq$ 5 mV, V_{OUT} = 35V T_A = 25°C		0.2	2	μA
Input Offset Voltage (Note 4)	$R_S \leq$ 5k			7	mV
Input Offset Current (Note 4)				100	nA
Input Bias Current				1000	nA
Input Voltage Range	V_S = ±15V V^+ = 5V, V^- = 0	 1	±13	 3	V V
Saturation Voltage	$V^+ \geq$ 4.5V, V^- = 0 $V_{IN} \leq$ −6 mV, $I_{SINK} \leq$ 3.2 mA $T_A \geq$ 0°C $T_A \leq$ 0°C		 0.23	 0.4 0.6	 V V
Output Leakage Current	$V_{IN} \geq$ 5 mV, V_{OUT} = 35V		1	10	μA
Differential Input Voltage				±5	V
Positive Supply Current	T_A = 25°C, V^+ = 5V, V^- = 0		4.3		mA
Positive Supply Current	T_A = 25°C V_S = ±15V		8	11.5	mA
Negative Supply Current	T_A = 25°C V_S = ±15V		3	4.5	mA

Note 1: For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.

Note 2: The maximum junction temperature of the LM119 is 150°C, while that of the LM219 is 110°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 3: These specifications apply for V_S = ±15V and −55°C ≤ T_A ≤ 125°C, unless otherwise stated. With the LM219, however, all temperature specifications are limited to −25°C ≤ T_A ≤ 85°C. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.

Voltage Comparators/Buffers

LM319 high speed dual comparator

general description

The LM319 is a precision high speed dual comparator fabricated on a single monolithic chip. It is designed to operate over a wide range of supply voltages down to a single 5V logic supply and ground. Further, it has higher gain and lower input currents than devices like the LM710. The uncommitted collector of the output stage makes the LM319 compatible with RTL, DTL and TTL as well as capable of driving lamps and relays at currents up to 25 mA.

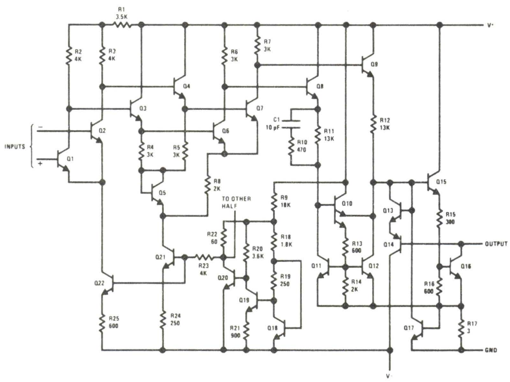
features

- Two independent comparators
- Operates from a single 5V supply
- Typically 80 ns response time at ±15V
- Minimum fan-out of 2 each side
- Maximum input current of 1 μA
- Inputs and outputs can be isolated from system ground
- High common mode slew rate

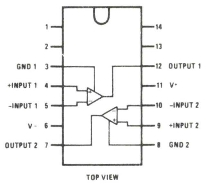
Although designed primarily for applications requiring operation from digital logic supplies, the LM319 is fully specified for power supplies up to ±15V. It features faster response than the LM111 at the expense of higher power dissipation. However, the high speed, wide operating voltage range and low package count make the LM319 much more versatile than older devices like the LM711.

The LM319 has its performance specified over a 0°C to 70°C temperature range.

schematic and connection diagrams



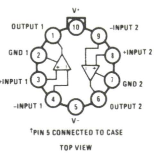
Dual In-Line-Package



Order Number LM319D
See package 1

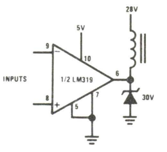
LM319N
See Package 22

Metal Can Package†

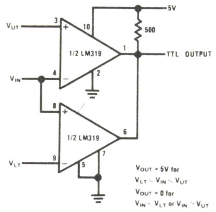


Order Number LH319H
See Package 12

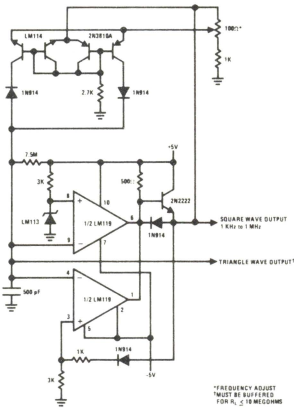
typical applications



Relay Driver



Window Detector



Wide Range Variable Oscillator

absolute maximum ratings

Total Supply Voltage	36V
Output to Negative Supply Voltage	36V
Ground to Negative Supply Voltage	25V
Ground to Positive Supply Voltage	18V
Differential Input Voltage	±5V
Input Voltage (Note 1)	±15V
Power Dissipation (Note 2)	500 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range LM319	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25°C$, $R_S \leq 5k$		2.0	8.0	mV
Input Offset Current (Note 4)	$T_A = 25°C$		80	200	nA
Input Bias Current	$T_A = 25°C$		250	1000	nA
Voltage Gain	$T_A = 25°C$	8	40		V/mV
Response Time (Note 5)	$T_A = 25°C$ $V_S = \pm 15V$		80		ns
Saturation Voltage	$V_{IN} \leq -10$ mV, $I_{OUT} = 25$ mA $T_A = 25°C$		0.75	1.5	V
Output Leakage Current	$V_{IN} \geq 10$ mV, $V_{OUT} = 35V$ $T_A = 25°C$		0.2	10	μA
Input Offset Voltage (Note 4)	$R_S \leq 5k$			10	mV
Input Offset Current (Note 4)				300	nA
Input Bias Current				1200	nA
Input Voltage Range	$V_S = \pm 15V$ $V^+ = 5V$, $V^- = 0$	 1	±13	 3	V V
Saturation Voltage	$V^+ \geq 4.5V$, $V^- = 0$ $V_{IN} \leq -10$ mV, $I_{SINK} \leq 3.2$ mA		0.3	0.4	V
Differential Input Voltage				±5	V
Positive Supply Current	$T_A = 25°C$, $V^+ = 5V$, $V^- = 0$		4.3		mA
Positive Supply Current	$T_A = 25°C$ $V_S = \pm 15V$		8	12.5	mA
Negative Supply Current	$T_A = 25°C$ $V_S = \pm 15V$		3	5	mA

Note 1: For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.

Note 2: The maximum junction temperature of the LM319 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15V$ and $0°C \leq T_A \leq 70°C$, unless otherwise stated. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.

Voltage Comparators/Buffers

LM139/LM239/LM339 quad comparators

general description

The LM139 series consists of four independent voltage comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM139 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM339 will directly interface with MOS logic — where the low power drain of the LM339 is a distinct advantage over standard comparators.

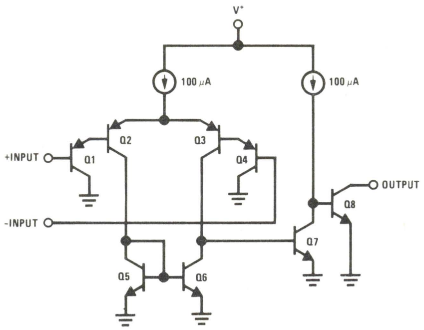
advantages

- Eliminates need for dual supplies
- Allows sensing near GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

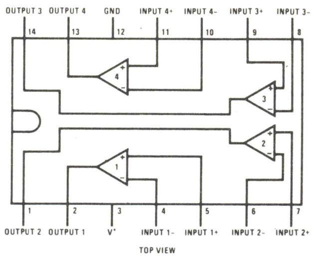
features

- Wide single supply
  Voltage range — $2\ V_{DC}$ to $36\ V_{DC}$
  or dual supplies — $\pm 1\ V_{DC}$ to $\pm 18\ V_{DC}$
- Very low supply current drain (0.8 mA) — independent of supply voltage (1 mW/comparator at $+5\ V_{DC}$)
- Low input biasing current — 35 nA
- Low input offset current — 3 nA
  and offset voltage — 3 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output — 1 mV at 5μA
  saturation voltage — 70 mV at 1 mA
- Output voltage compatible with TTL (fanout of 3), DTL, ECL, MOS and CMOS logic systems

schematic and connection diagrams

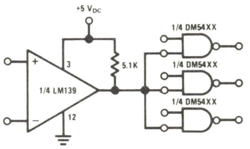


Dual-In-Line and Flat Package

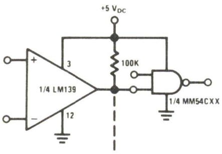


Order Number LM139F See Package 4	Order Number LM139D, LM239D, or LM339D See Package 1	Order Number LM339N See Package 22

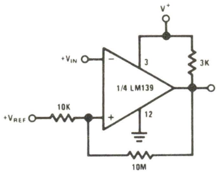
typical applications ($V^+ = 5\ V_{DC}$)



Driving TTL



Driving CMOS



Comparator with Hysteresis

absolute maximum ratings

Supply Voltage, V^+	36 V_{DC} or ±18 V_{DC}
Differential Input Voltage	36 V_{DC}
Input Voltage	–0.3 V_{DC} to +36 V_{DC}
Power Dissipation (Note 1)	
Molded DIP (LM339N)	570 mW
Cavity DIP (LM139D, LM239D & LM339D)	900 mW
Flat Pack (LM139F)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
Operating Temperature Range	
LM339	0°C to +70°C
LM239	–25°C to +85°C
LM139	–55°C to +125°C
Storage Temperature Range	–65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (V^+ = +5 V_{DC} and T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	LM139			LM239, LM339			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	At Output Switch Point, $V_O \cong 1.4\ V_{DC}$, V_{REF} = +1.4 V_{DC} and R_S = 0Ω		2	5		2	5	mV_{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$ With Output in Linear Range		25	100		25	250	nA_{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		3	25		5	50	nA_{DC}
Input Common-Mode Voltage Range (Note 4)		0		V^+ –1.5	0		V^+ –1.5	V_{DC}
Supply Current	$R_L = \infty$ On All Comparators		0.8	2		0.8	2	mA_{DC}
Voltage Gain	R_L = 15 kΩ		200			200		V/mV
Response Time (Note 5)	V_{RL} = 5.0 V_{DC} and R_L = 5.1 kΩ		1.3			1.3		μs
Output Sink Current	$V_{IN(-)}$ = +1 V_{DC}, $V_{IN(+)}$ = 0 and $V_O \leq$ + 1.5 V_{DC}	6	16		6	16		mA_{DC}
Saturation Voltage	$V_{IN(-)}$ = +1 V_{DC}, $V_{IN(+)}$ = 0 and I_{SINK} = 3 mA		200	400		200	400	mV_{DC}
Output Leakage Current	$V_{IN(+)}$ = +1 V_{DC}, $V_{IN(-)}$ = 0 and V_{OUT} = 5 V_{DC}		0.1			0.1		nA_{DC}

Note 1: For operating at high temperatures, the LM339 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM239 and LM139 must be derated based on a +150°C maximum junction temperature. The low bias dissipation and the ON-OFF characteristic of the outputs keeps the chip dissipation very small (Pd $\leq$ 100 mW), provided the output transistors are allowed to saturate.

Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of V^+.

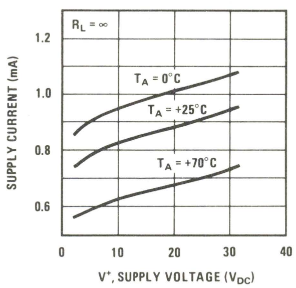
Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V^+ – 1.5V, but either or both inputs can go to +30 V_{DC} without damage.

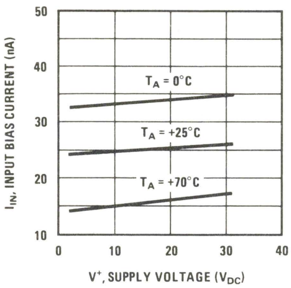
Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained, see typical performance characteristics section.

typical performance characteristics

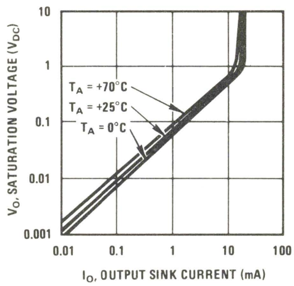
Supply Current



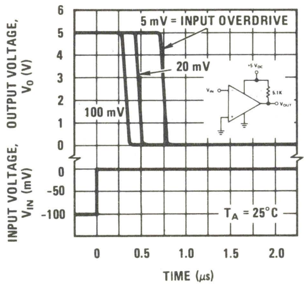
Input Current



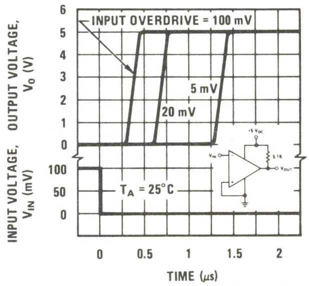
Output Saturation Voltage



Response Time for Various Input Overdrives – Negative Transition



Response Time for Various Input Overdrives – Positive Transition



application hints

The LM139 is a high gain, wide bandwidth device; which, like most comparators, can easily oscillate if the output lead is inadvertently allowed to capacitively couple to the inputs via stray capacitance. This shows up only during the output voltage transition intervals as the comparator changes states. Power supply bypassing is not required to solve this problem. Standard PC board layout is helpful as it reduces stray input-output coupling. Reducing the input resistors to <10 kΩ reduces the feedback signal levels and finally, adding even a small amount (1 to 10 mV) of positive feedback (hysteresis) causes such a rapid transition that oscillations due to stray feedback are not possible. Simply socketing the IC and attaching resistors to the pins will cause input-output oscillations during the small transition intervals unless hysteresis is used. If the input signal is a pulse waveform, with relatively fast rise and fall times, hysteresis is not required.

All pins of any unused comparators should be grounded.

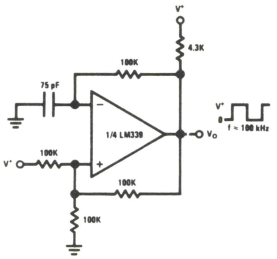
The bias network of the LM139 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from $2V_{DC}$ to $30\ V_{DC}$.

It is usually unnecessary to use a bypass capacitor across the power supply line.

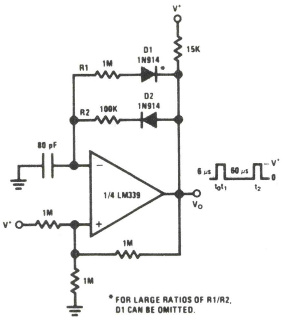
The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3\ V_{DC}$ (at 25°C). An input clamp diode can be used as shown in the applications section.

The output of the LM139 is the uncommitted collector of a grounded-emitter NPN output transistor. Many collectors can be tied together to provide an output OR'ing function. An output pull-up resistor can be connected to any available power supply voltage within the permitted supply voltage range and there is no restriction on this voltage due to the magnitude of the voltage which is applied to the V^+ terminal of the LM139 package. The output can also be used as a simple SPST switch to ground (when a pull-up resistor is not used). The amount of current which the output device can sink is limited by the drive available (which is independent of V^+) and the β of this device. When the maximum current limit is reached (approximately 16 mA), the output transistor will come out of saturation and the output voltage will rise very rapidly. The output saturation voltage is limited by the approximately 60Ω r_{sat} of the output transistor. The low offset voltage of the output transistor (1 mV) allows the output to clamp essentially to ground level for small load currents.

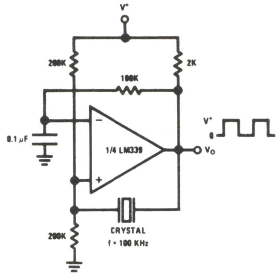
typical applications (con't) ($V^+ = 15\ V_{DC}$)



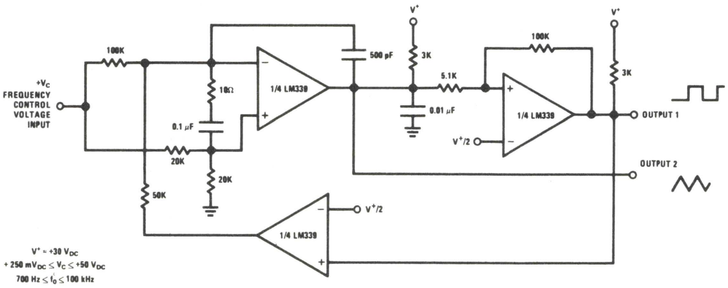
Squarewave Oscillator



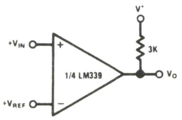
Pulse Generator



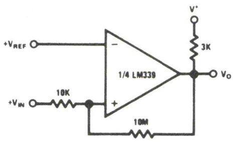
Crystal Controlled Oscillator



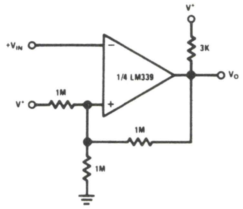
Two-Decade High-Frequency VCO



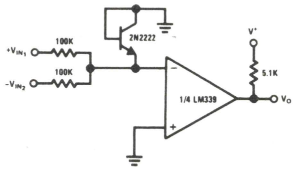
Basic Comparator



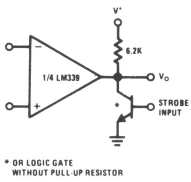
Non-Inverting Comparator with Hysteresis



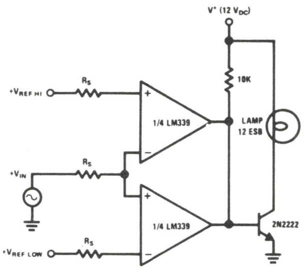
Inverting Comparator with Hysteresis



Comparing Input Voltages of Opposite Polarity

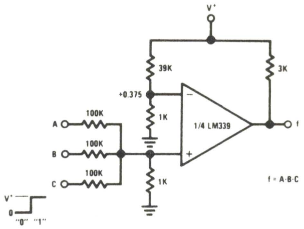


Output Strobing

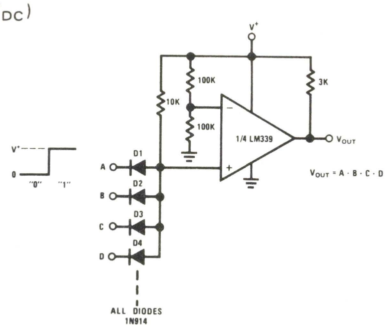


Limit Comparator

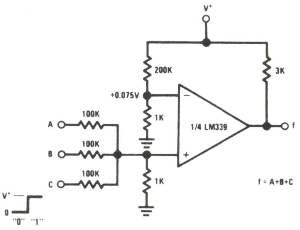
typical applications (con't) ($V^+ = 15\ V_{DC}$)



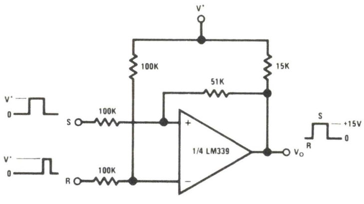
AND Gate



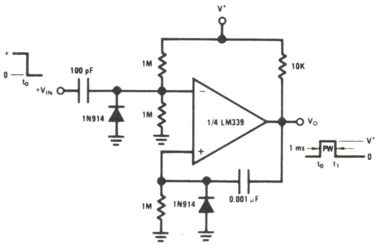
Large Fan-in AND Gate



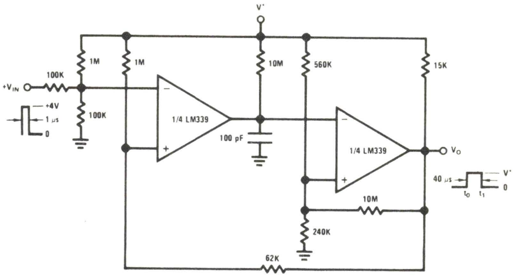
OR Gate



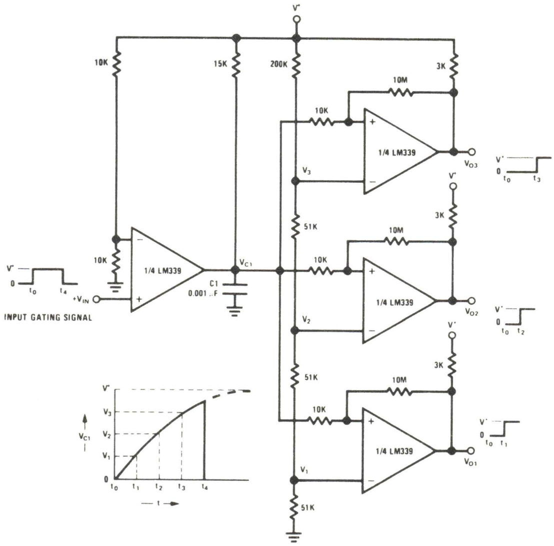
Bi-Stable Multivibrator



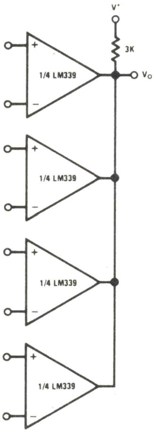
One-Shot Multivibrator



One-Shot Multivibrator with Input Lock Out

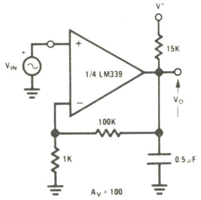


Time Delay Generator

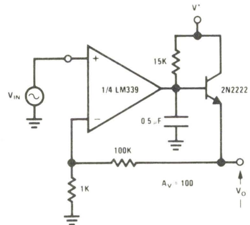


ORing the Outputs

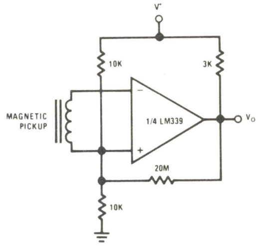
typical applications (con't) ($V^+ = 15\ V_{DC}$)



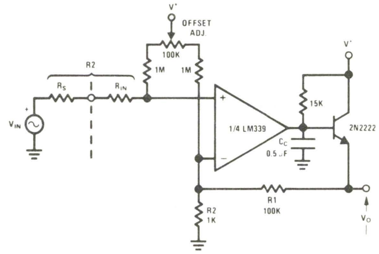
Low Frequency Op Amp



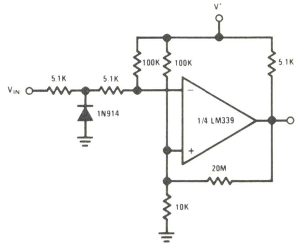
Low Frequency Op Amp ($V_O = 0V$ for $V_{IN} = 0V$)



Transducer Amplifier

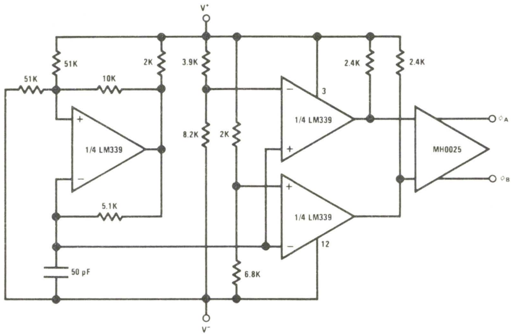


Low Frequency Op Amp with Offset Adjust

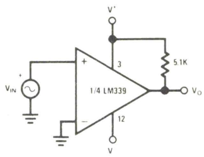


Zero Crossing Detector (Single Power Supply)

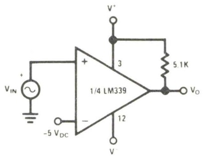
split-supply applications ($V^+ = +15\ V_{DC}$ & $V^- = -15\ V_{DC}$)



MOS Clock Driver



Zero Crossing Detector



Comparator With a Negative Reference

Voltage Comparators/Buffers

LM139A/LM239A/LM339A low offset voltage quad comparators

general description

The LM139A series consists of four independent precision voltage comparators with an offset voltage specification of 2 mV max. for all four comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM139A series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM339A will directly interface with MOS logic — where the low power drain of the LM339A is a distinct advantage over standard comparators.

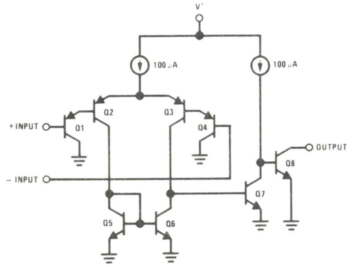
advantages

- High precision comparators
- Reduced V_{OS} drift over temperature
- Eliminates need for dual supplies
- Allows sensing near GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

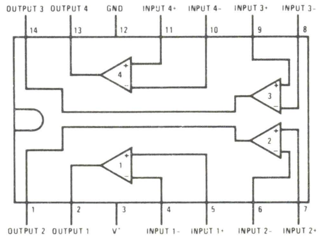
features

- Wide single supply
  Voltage range $2\ V_{DC}$ to $36\ V_{DC}$
  or dual supplies $\pm 1\ V_{DC}$ to $\pm 18\ V_{DC}$
- Very low supply current drain (0.8 mA) — independent of supply voltage (2 mW/comparator at $+5\ V_{DC}$)
- Low input biasing current 35 nA
- Low input offset current 3 nA
  and maximum offset voltage 2 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output 1 mV at 5µA
  saturation voltage 70 mV at 1 mA
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems

schematic and connection diagrams



Dual-In-Line and Flat Package



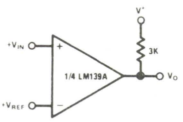
TOP VIEW

Order Number LM139AF
See Package 4

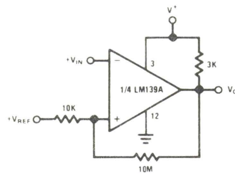
Order Number LM139AD, LM239AD or LM339AD
See Package 1

Order Number LM339AN
See Package 22

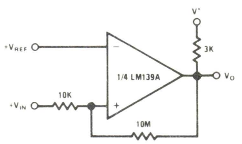
typical applications ($V^+ = 5\ V_{DC}$)



Basic Comparator



Comparator with Hysteresis



Non-Inverting Comparator with Hysteresis

absolute maximum ratings

Supply Voltage, V^+	36 V_{DC} or ±18 V_{DC}
Differential Input Voltage	36 V_{DC}
Input Voltage	−0.3 V_{DC} to +36 V_{DC}
Power Dissipation (Note 1)	
Molded DIP (LM339AN)	570 mW
Cavity DIP (LM139AD, LM239AD & LM339AD)	900 mW
Flat Pack (LM139AF)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
Operating Temperature Range	
LM339A	0°C to +70°C
LM239A	−25°C to +85°C
LM139A	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (V^+ = 15 V_{DC} and T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	LM139A			LM239A, LM339A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	At Output Switch Point, $V_O \cong 1.4\ V_{DC}$, V_{REF} = +1.4 V_{DC} and R_S = 0Ω		1	2		1	2	mV_{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$ With Output in Linear Range		25	100		25	250	nA_{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		3	25		5	50	nA_{DC}
Input Common-Mode Voltage Range (Note 4)				V^+ −1.5			V^+ −1.5	V_{DC}
Supply Current	$R_L = \infty$ On All Comparators		.8	2		.8	2	mA_{DC}
Voltage Gain	R_L = 15 kΩ		200			200		V/mV
Response Time (Note 5)	V_{RL} = 5.0 V_{DC} and R_L = 5.1 kΩ		1.3			1.3		μs
Output Sink Current	$V_{IN(-)}$ = +1 V_{DC}, $V_{IN(+)}$ = 0 and $V_O \leq$ + 1.5 V_{DC}	6	16		6	16		mA_{DC}
Saturation Voltage	$V_{IN(-)}$ = +1 V_{DC}, $V_{IN(+)}$ = 0 and I_{SINK} = 3 mA		200	400		200	400	mV_{DC}
Output Leakage Current	$V_{IN(+)}$ = +1 V_{DC}, $V_{IN(-)}$ = 0 and V_{OUT} = 5 V_{DC}		0.1			.1		nA_{DC}

Note 1: For operating at high temperatures, the LM339A must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM239A and LM139A must be derated based on a +150°C maximum junction temperature. The low bias dissipation and the ON-OFF characteristic of the outputs keeps the chip dissipation very small (Pd ≤ 100 mW), provided the output transistors are allowed to saturate.

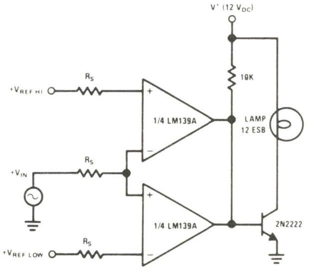
Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of V^+.

Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

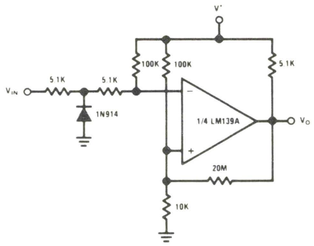
Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V^+ − 1.5V, but either or both inputs can go to +30 V_{DC} without damage.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained, see typical performance characteristics section.

typical applications (con't) (V^+ = 5 V_{DC})



Limit Comparator



Zero Crossing Detector (Single Power Supply)

For more applications and design information, see LM139 data sheet.

Voltage Comparators/Buffers

LM160/LM260/LM360 high speed differential comparator

general description

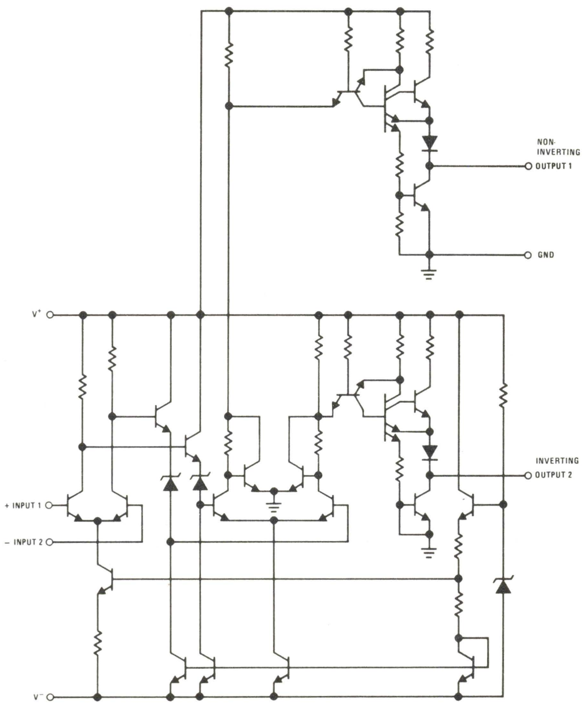
The LM160/LM260/LM360 is a very high speed differential input, complementary TTL output voltage comparator with improved characteristics over the μA760/μA760C, for which it is a pin-for-pin replacement. The device has been optimized for greater speed, input impedance and fan-out, and lower input offset voltage. Typically delay varies only 3 ns for overdrive variations of 5 mV to 500 mV.

Complementary outputs having minimum skew are provided. Applications involve high speed analog to digital convertors and zero-crossing detectors in disc file systems.

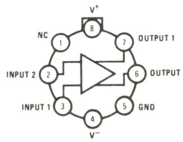
features

- Guaranteed high speed 20 ns max
- Tight delay matching on both outputs
- Complementary TTL outputs
- High input impedance
- Low speed variation with overdrive variation
- Fan-out of 4
- Low input offset voltage
- Series 74 TTL compatible

schematic and connection diagrams



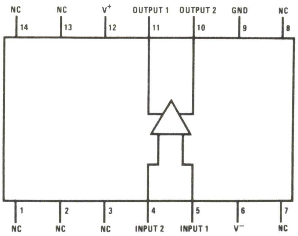
Metal Can Package



TOP VIEW

Order Number LM160H, LM260H, or LM360H
See Package 11

Dual-In-Line and Flat Packages



TOP VIEW

Order Number LM360N
See Package 22

or

Order Number LM160D, LM260D, or LM360D
See Package 1

or

Order Number LM160F
See Package 4

absolute maximum ratings

Positive Supply Voltage	+8V	Operating Temperature Range	
Negative Supply Voltage	−8V	LM160	−55°C to +125°C
Peak Output Current	20 mA	LM260	−25°C to +85°C
Differential Input Voltage	±5V	LM360	0°C to +70°C
Input Voltage	$V^+ \geq V_{IN} \geq V^-$	Storage Temperature Range	−65°C to +150°C
		Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($T_{MIN} \leq T_A \leq T_{MAX}$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Conditions					
Supply Voltage V_{CC}^+		4.5	5	6.5	V
Supply Voltage V_{CC}^-		−4.5	−5	−6.5	V
Input Offset Voltage	$R_S \leq 200\Omega$		1		mV
Input Offset Current			.5		μA
Input Bias Current			5		μA
Output Resistance (Either Output)	$V_{OUT} = V_{OH}$		100		Ω
Response Time	$T_A = 25°C$, $V_S = \pm 5V$ (Note 1)		16	30	ns
	$T_A = 25°C$, $V_S = \pm 5V$ (Note 2)			25	ns
	$T_A = 25°C$, $V_S = \pm 5V$ (Note 3)		14		ns
Response Time Difference Between Outputs					
(t_{pd} of $+V_{IN1}$) − (t_{pd} of $-V_{IN2}$)	$T_A = 25°C$, (Note 1)		2		ns
(t_{pd} of $+V_{IN2}$) − (t_{pd} of $-V_{IN1}$)	$T_A = 25°C$, (Note 1)		2		ns
(t_{pd} of $+V_{IN1}$) − (t_{pd} of $+V_{IN2}$)	$T_A = 25°C$, (Note 1)		2		ns
(t_{pd} of $-V_{IN1}$) − (t_{pd} of $-V_{IN2}$)	$T_A = 25°C$, (Note 1)		2		ns
Input Resistance	f = 1 MHz		17		kΩ
Input Capacitance	f = 1 MHz		3		pF
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\Omega$		5		μV/°C
Average Temperature Coefficient of Input Offset Current			7		nA/°C
Common Mode Input Voltage Range	$V_S = \pm 6.5V$	±4	±4.5		V
Differential Input Voltage Range		±5			V
Output High Voltage (Either Output)	$I_{OUT} = -320\mu A$, $V_S = \pm 4.5V$	2.4	3		V
Output Low Voltage (Either Output)	$I_{SINK} = 6.4$ mA		.25	.4	V
Positive Supply Current	$V_S = \pm 6.5V$		18	32	mA
Negative Supply Current	$V_S = \pm 6.5V$		−9	−16	mA

Note 1: Response time measured from the 50% point of a 30 mV_{P-P} 10 MHz sinusoidal input to the 50% point of the output.
Note 2: Response time measured from the 50% point of a 2 V_{P-P} 10 MHz sinusoidal input to the 50% point of the output.
Note 3: Response time measured from the start of a 100 mV input step with 5 mV overdrive to the time when the output crosses the logic threshold.

Voltage Comparators/Buffers

LM161/LM261/LM361 high speed differential comparators

general description

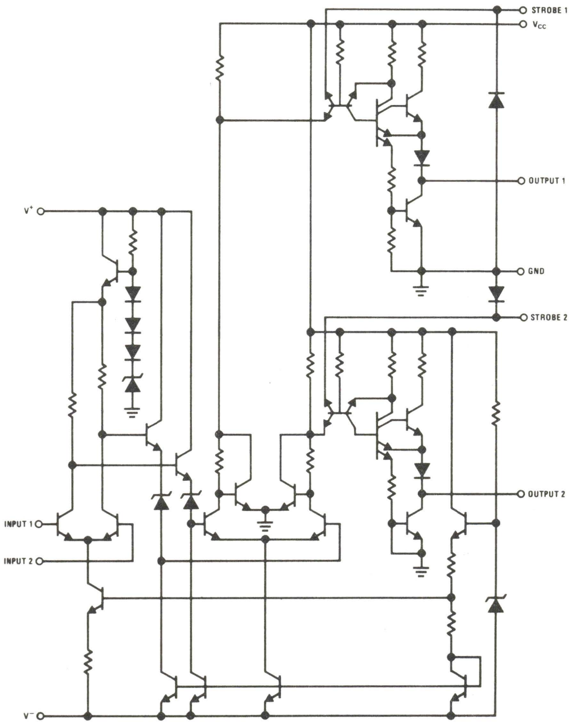
The LM161/LM261/LM361 is a very high speed differential input, complementary TTL output voltage comparator with improved characteristics over the SE529/NE529 for which it is a pin-for-pin replacement. The device has been optimized for greater speed performance and lower input offset voltage. Typically delay varies only 3 ns for over-drive variations of 5 mV to 500 mV. It may be operated from op amp supplies (±15V).

Complementary outputs having minimum skew are provided. Applications involve high speed analog to digital convertors and zero-crossing detectors in disc file systems.

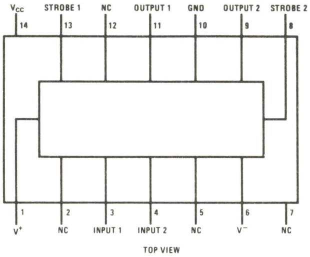
features

- Independent strobes
- Guaranteed high speed 20 ns max
- Tight delay matching on both outputs
- Complementary TTL outputs
- Operates from op amp supplies ±15V
- Low speed variation with overdrive variation
- Low input offset voltage
- Versatile supply voltage range

schematic and connection diagrams

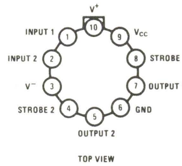


Dual-In-Line and Flat Package



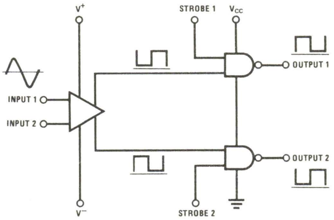
Order Number LM361N
See Package 22
or
Order Number LM161D, LM261D or LM361D
See Package 1
or
Order Number LM161F
See Package 4

Metal Can Package



Order Number LM161H or LM261H
See Package 11

logic diagram



absolute maximum ratings

Positive Supply Voltage, V^+	+16V
Negative Supply Voltage, V^-	−16V
Gate Supply Voltage, V_{CC}	+7V
Output Voltage	+7V
Differential Input Voltage	±5V
Input Common Mode Voltage	±6V
Power Dissipation	600 mW
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
LM161	−55°C to +125°C
LM261	−25°C to +85°C
LM361	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

operating conditions

	MIN	TYP	MAX
Supply Voltage V^+			
LM161/LM261	5V		15V
LM361	5V		15V
Supply Voltage V^-			
LM161/LM261	−6V		−15V
LM361	−6V		−15V
Supply Voltage V_{CC}			
LM161/LM261	4.5V	5V	5.5V
LM361	4.75V	5V	5.25V

electrical characteristics ($V^+ = +10V$, $V_{CC} = +5V$, $V^- = -10V$, $T_{MIN} \le T_A \le T_{MAX}$, unless noted)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM161/LM261			LM361			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$		1			1		mV
Input Bias Current	$T_A = 25°C$		5	10 36		5	20 50	μA
Input Offset Current	$T_A = 25°C$		2	3 9		2	5 15	μA
Voltage Gain	$T_A = 25°C$		5			5		V/mV
Input Resistance	$T_A = 25°C$, f = 1 kHz		20			20		kΩ
Logical "1" Output Voltage	$V_{CC} = 4.75V$, $I_{SOURCE} = -.5$ mA	2.4	3.3		2.4	3.3		V
Logical "0" Output Voltage	$V_{CC} = 4.75V$, $I_{SINK} = 6.4$ mA			.4			.4	V
Strobe Input "1" Current	$V_{CC} = 5.25V$, $V_{STROBE} = 2.4V$			200			200	μA
	$T_A = 25°C$			50			100	μA
Strobe Input "0" Current	$V_{CC} = 5.25V$, $V_{STROBE} = .4V$			−1.6			−1.6	mA
Strobe Input "0" Voltage	$V_{CC} = 4.75V$			.8			.8	V
Strobe Input "1" Voltage	$V_{CC} = 4.75V$	2			2			V
Output Short Circuit Current	$V_{CC} = 5.25V$, $V_{OUT} = 0V$	−18		−55	−18		−55	mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125°C$			3.25				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25°C$			3.75				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55°C$			4				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0°C \le T_A \le 70°C$						5	mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125°C$			7				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25°C$			7.5				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55°C$			8.5				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0°C \le T_A \le 70°C$						10	mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125°C$			15				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25°C$			16				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55°C$			18				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0°C \le T_A \le 70°C$						20	mA
TRANSIENT RESPONSE	$V_{IN} = 50$ mV Overdrive							
Propagation Delay Time ($t_{pd(0)}$)	$T_A = 25°C$		11	20		11	20	ns
Propagation Delay Time ($t_{pd(1)}$)	$T_A = 25°C$		12	22		12	22	ns
Delay Between Output A and B	$T_A = 25°C$		2	5		2	5	ns
Strobe Delay Time ($t_{pd(0)}$)	$T_A = 25°C$		6			6		ns
Strobe Delay Time ($t_{pd(1)}$)	$T_A = 25°C$		6			6		ns

Voltage Comparators/Buffers

LM710 voltage comparator

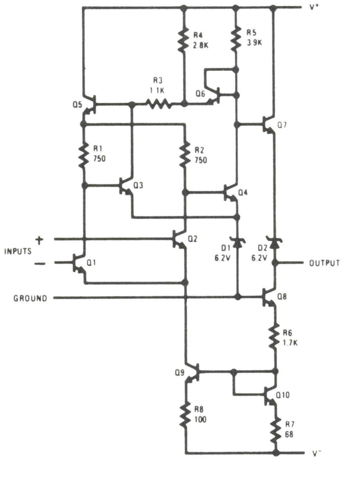
general description

The LM710 is a high-speed voltage comparator intended for use as an accurate, low-level digital level sensor or as a replacement for operational amplifiers in comparator applications where speed is of prime importance. The circuit has a differential input and a single-ended output, with saturated output levels compatible with practically all types of integrated logic.

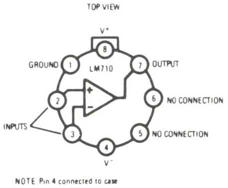
The device is built on a single silicon chip which insures low offset and thermal drift. The use of a minimum number of stages along with minority-carrier lifetime control (gold doping) makes the circuit much faster than operational amplifiers in saturating comparator applications. In fact, the low stray and wiring capacitances that can be realized with monolithic construction make the device difficult to duplicate with discrete components operating at equivalent power levels.

The LM710 is useful as a pulse height discriminator, a voltage comparator in high-speed A/D converters or a go, no-go detector in automatic test equipment. It also has applications in digital systems as an adjustable-threshold line receiver or an interface between logic types. In addition, the low cost of the unit suggests it for applications replacing relatively simple discrete component circuitry.

schematic* and connection diagrams



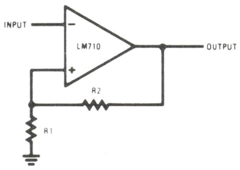
Metal Can



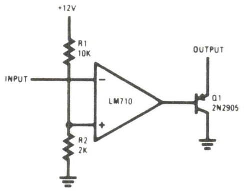
Order Number LM710H
See Package 11

typical applications*

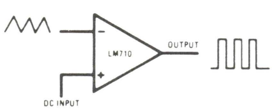
Schmidt Trigger



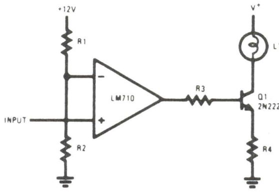
Line Receiver With Increased Output Sink Current



Pulse Width Modulator



Level Detector With Lamp Driver



*Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	14.0V
Negative Supply Voltage	−7.0V
Peak Output Current	10 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Power Dissipation	
TO-99 (Note 1)	300 mW
Flat Package (Note 2)	200 mW
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S \le 200\Omega$ $V_{CM} = 0V$		0.6	2.0	mV
Input Offset Current	$T_A = 25°C$, $V_{OUT} = 1.4V$		0.75	3.0	μA
Input Bias Current	$T_A = 25°C$		13	20	μA
Voltage Gain	$T_A = 25°C$	1250	1700		
Output Resistance	$T_A = 25°C$		200		Ω
Output Sink Current	$T_A = 25°C$, $V_{IN} \le -5$ mV $V_{OUT} = 0$	2.0	2.5		mA
Response Time (Note 4)	$T_A = 25°C$		40		ns
Input Offset Voltage	$R_S \le 200\Omega$, $V_{CM} = 0V$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage	$-55°C \le T_A \le 125°C$ $R_S \le 50\Omega$		3.0	10	μV/°C
Input Offset Current	$T_A = 125°C$ $T_A = -55°C$		0.25 1.8	3.0 7.0	μA μA
Average Temperature Coefficient of Input Offset Current	$25°C \le T_A \le 125°C$ $-55°C \le T_A \le 25°C$		5.0 15	25 75	nA/°C nA/°C
Input Bias Current	$T_A = -55°C$		27	45	μA
Input Voltage Range	$V^- = -7.0V$	±5.0			V
Common Mode Rejection Ratio	$R_S \le 200\Omega$	80	100		dB
Differential Input Voltage Range		±5.0V			V
Voltage Gain		1000			
Positive Output Level	$V_{IN} \ge 5$ mV, $0 \le I_{OUT} \le -5$ mA	2.5	3.2	4.0	V
Negative Output Level	$V_{IN} \le -5$ mV	−1.0	−0.5	0	V
Output Sink Current	$T_A = 125°C$, $V_{IN} \le -5$ mV $V_{OUT} = 0V$	0.5	1.7		mA
	$T_A = -55°C$, $V_{IN} \le -5$ mV $V_{OUT} = 0$	1.0	2.3		mA
Positive Supply Current	$V_{IN} \le -5$ mV		5.2	9.0	mA
Negative Supply Current			4.6	7.0	mA
Power Consumption	$V_{IN} \le -5$ mV $I_{OUT} = 0$ mA		90	150	mW

Note 1: Rating applies for case temperatures to +125°C; derate linearly at 5.6 mW/°C for ambient temperatures above +105°C.

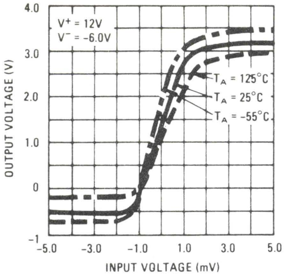
Note 2: Derate linearly at 4.4 mW/°C for ambient temperatures above +100°C.

Note 3: These specifications apply for $V^+ = 12.0V$, $V^- = -6.0V$, $-55°C \le T_A \le +125°C$ unless otherwise specified. The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.8V at −55°C, 1.4V at +25°C, and 1.0V at +125°C.

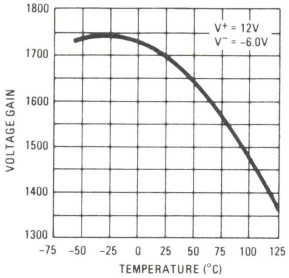
Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics

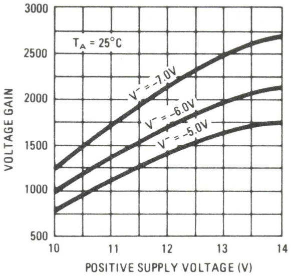
Transfer Function



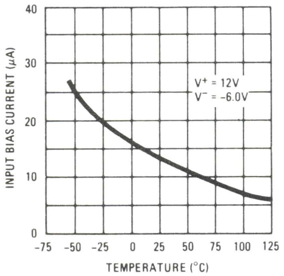
Voltage Gain



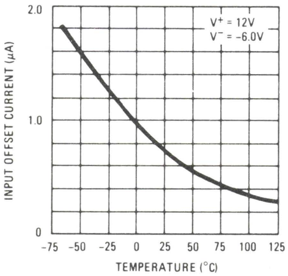
Voltage Gain



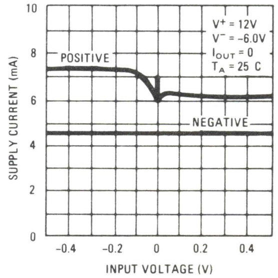
Input Bias Current



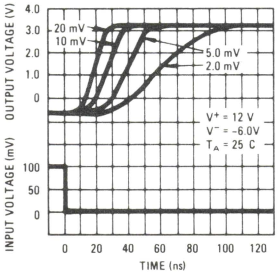
Input Offset Current



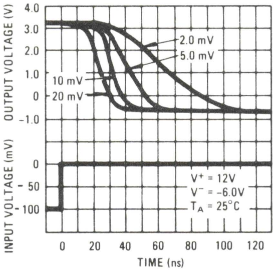
Supply Current



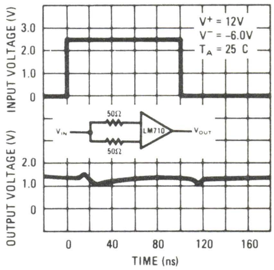
Response Time For Various Input Overdrives



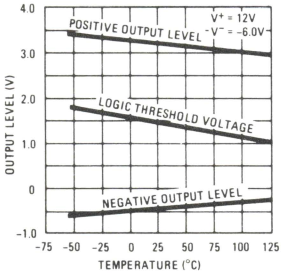
Response Time For Various Input Overdrives



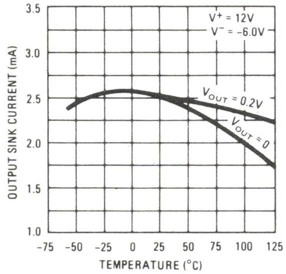
Common Mode Pulse Response



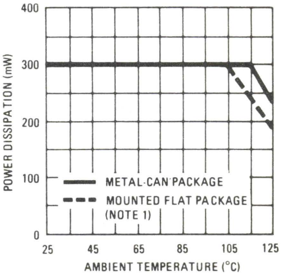
Output Voltage Level



Output Sink Current



Maximum Power Dissipation



Voltage Comparators/Buffers

LM710C voltage comparator

general description

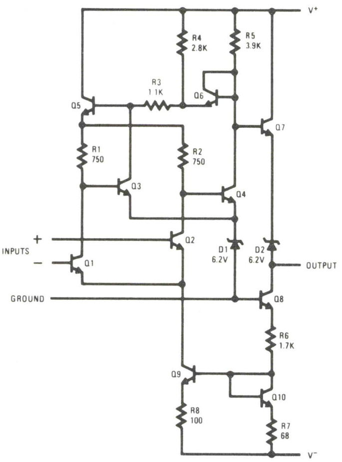
The LM710C is a high-speed voltage comparator intended for use as an accurate, low-level digital level sensor or as a replacement for operational amplifiers in comparator applications where speed is of prime importance. The circuit has a differential input and a single-ended output, with saturated output levels compatible with practically all types of integrated logic.

The device is built on a single silicon chip which insures low offset and thermal drift. The use of a minimum number of stages along with minority-carrier lifetime control (gold doping) makes the circuit much faster than operational amplifiers in saturating comparator applications. In fact, the low stray and wiring capacitances that can be realized with monolithic construction make the device difficult to duplicate with discrete components operating at equivalent power levels.

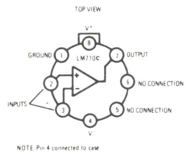
The LM710C is useful as a pulse height discriminator, a voltage comparator in high-speed A/D converters or a go, no-go detector in automatic test equipment. It also has applications in digital systems as an adjustable-threshold line receiver or an interface between logic types. In addition, the low cost of the unit suggests it for applications replacing relatively simple discrete component circuitry.

The LM710C is the commercial/industrial version of the LM710A. It is identical to the LM710A except that operation is specified over a 0°C to 70°C temperature range.

schematic* and connection diagrams

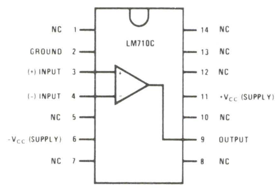


Metal Can Package



Order Number LM710CH
See Package 11

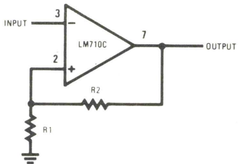
Dual-In-Line Package



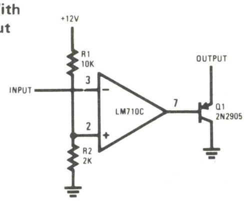
Order Number LM710CN
See Package 22

typical applications*

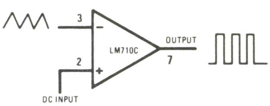
Schmidt Trigger



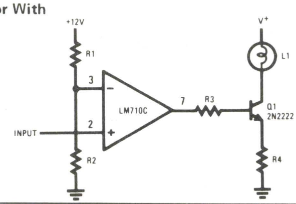
Line Receiver With Increased Output Sink Current



Pulse Width Modulator



Level Detector With Lamp Driver



*Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	14.0V
Negative Supply Voltage	−7.0V
Peak Output Current	10 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Power Dissipation (Note 1)	
TO-99	300 mW
Flat Package	200 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25°C$, $R_S < 200\Omega$ $V_{CM} = 0V$		1.6	5.0	mV
Input Offset Current	$T_A = 25°C$, $V_{OUT} = 1.4V$		1.8	5.0	μA
Input Bias Current	$T_A = 25°C$		16	25	μA
Voltage Gain	$T_A = 25°C$	1000	1500		
Output Resistance	$T_A = 25°C$		200		Ω
Output Sink Current	$T_A = 25°C$, $\Delta V_{IN} \geq 10$ mV $V_{OUT} = 0$	1.6	2.5		mA
Response Time (Note 3)	$T_A = 25°C$		40		ns
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0V$			6.5	mV
Average Temperature Coefficient of Input Offset Voltage	$0°C \leq T_A \leq 70°C$ $R_S \leq 50\Omega$		5.0	20	μV/°C
Input Offset Current				7.5	μA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 70°C$ $0°C \leq T_A \leq 25°C$		15 24	50 100	nA/°C nA/°C
Input Bias Current	$T_A = 0°C$		25	40	μA
Input Voltage Range	$V^- = -7.0V$	±5.0			V
Common Mode Rejection Ratio	$R_S \leq 200\Omega$	70	98		dB
Differential Input Voltage Range		±5.0			V
Voltage Gain		800			
Positive Output Level	$V_{IN} \geq 10$ mV $0 \leq I_{OUT} \leq -5$ mA	2.5	3.2	4.0	V
Negative Output Level	$V_{IN} \leq -10$ mV	−1.0	−0.5	0	V
Output Sink Current	$V_{IN} \leq -10$ mV, $V_{OUT} = 0V$	0.5			mA
Positive Supply Current	$V_{IN} \leq -10$ mV		5.2	9.0	mA
Negative Supply Current			4.6	7.0	mA
Power Consumption				150	mW

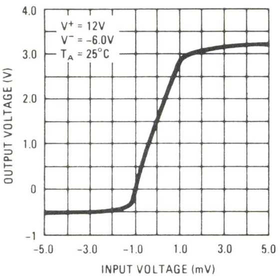
Note 1: Ratings apply for ambient temperatures to 70°C.

Note 2: These specifications apply for $V^+ = 12.0V$, $V^- = 6.0V$, $0°C \leq T_A \leq 70°C$ unless otherwise specified. The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.5V at 0°C, 1.4V at 25°C and 1.2V at 70°C.

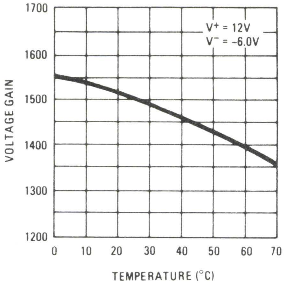
Note 3: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics

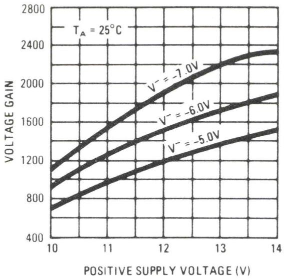
Transfer Function



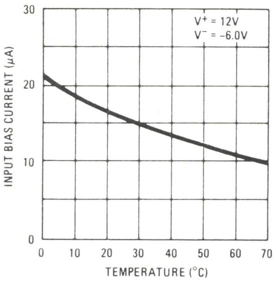
Voltage Gain



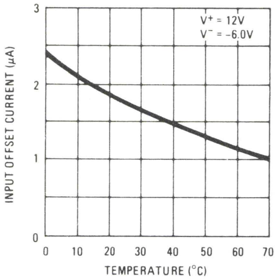
Voltage Gain



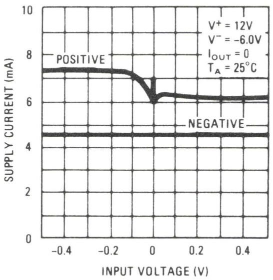
Input Bias Current



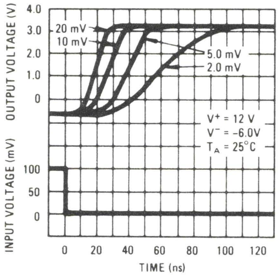
Input Offset Current



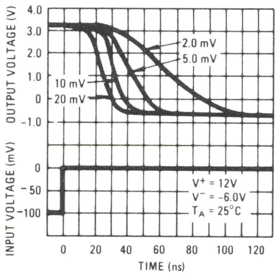
Supply Current



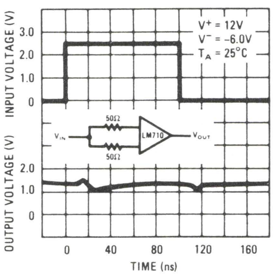
Response Time For Various Input Overdrives



Response Time For Various Input Overdrives



Common Mode Pulse Response



Voltage Comparators/Buffers

LM711 dual comparator

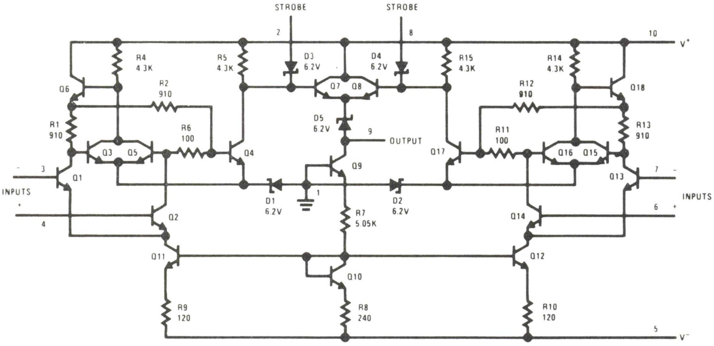
general description

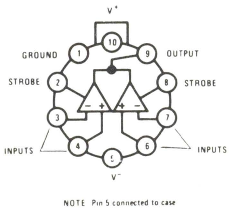
The LM711 contains two voltage comparators with separate differential inputs, a common output and provision for strobing each side independently. Similar to the LM710, the device features low offset and thermal drift, a large input voltage range, low power consumption, fast recovery from large overloads and compatibility with most integrated logic circuits.

With the addition of an external resistor network, the LM711 can be used as a sense amplifier for core memories. The input thresholding, combined with the high gain of the comparator, eliminates many of the inaccuracies encountered with conventional sense amplifier designs. Further, it has the speed and accuracy needed for reliably detecting the outputs of cores as small as 20 mils.

The LM711 is also useful in other applications where a dual comparator with OR'ed outputs is required, such as a double-ended limit detector. By using common circuitry for both halves, the device can provide high speed with lower power dissipation than two single comparators. The LM711 is available in either an 10-lead low profile TO-5 header or a 1/4" by 1/4" metal flat package.

schematic** and connection diagrams

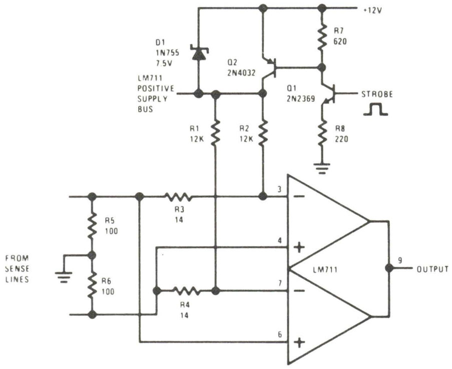




Order Number LM711H
See Package 14

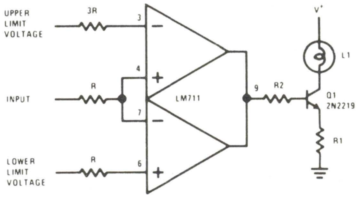
typical applications**

Sense Amplifier With Supply Strobing for Reduced Power Consumption*



*Standby dissipation is about 40 mW

Double-Ended Limit Detector With Lamp Driver



**Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	+14.0V
Negative Supply Voltage	−7.0V
Peak Output Current	25 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Strobe Voltage	0 to +6.0V
Internal Power Dissipation (Note 1)	300 mW
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (These specifications apply for T_A = 25°C, V^+ = 12V, V^- = −6V)

PARAMETER	CONDITIONS (Note 2)	MIN.	TYP.	MAX.	UNIT
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$		1.0	3.5	mV
	$R_S \leq 200\Omega$, $-5V \leq V_{CM} \leq +5V$		1.0	5.0	mV
Input Offset Current			0.5	10.0	μA
Input Bias Current			25	75	μA
Voltage Gain		750	1500		
Response Time (Note 3)			40		ns
Strobe Release Time			12		ns
Input Voltage Range	$V^- = -7.0V$	±5.0			V
Differential Input Voltage Range		±5.0			V
Output Resistance			200		Ω
Positive Output Level	$V_{IN} \geq 10$ mV		4.5	5.0	V
Loaded Positive Output Level	$V_{IN} \geq 10$ mV, $I_{OUT} = -5$ mA	2.5	3.5		V
Negative Output Level	$V_{IN} \leq -10$ mV	−1.0		0	V
Strobed Output Level	$V_{STROBE} \leq 0.3V$	−1.0		0	V
Output Sink Current	$V_{IN} \leq -10$ mV, $V_{OUT} \geq 0$	0.5	0.8		mA
Strobe Current	$V_{STROBE} = 100$ mV		1.2	2.5	mA
Positive Supply Current	$V_{IN} \leq -10$ mV		8.6		mA
Negative Supply Current			3.9		mA
Power Consumption			130	200	mW
The following specifications apply for $-55°C \leq T_A \leq 125°C$:					
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$			4.5	mV
	$R_S \leq 200\Omega$			6.0	mV
Input Offset Current				20	μA
Input Bias Current				150	μA
Average Temperature Coefficient of Input Offset Voltage			5.0		μV/°C
Voltage Gain		500			

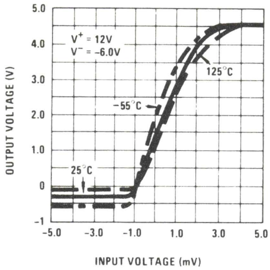
Note 1: Rating applies for case temperatures to +125°C; derate linearly at 5.6 mW/°C for ambient temperatures above 105°C.

Note 2: The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.8V at −55°C, 1.4V at +25°C, and 1.0V at +125°C.

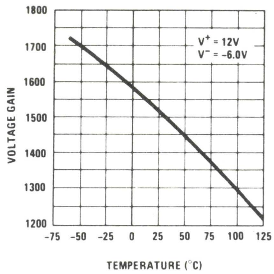
Note 3: The response time specified is for a 100 mV input step with 5 mV overdrive (see definitions).

typical performance characteristics

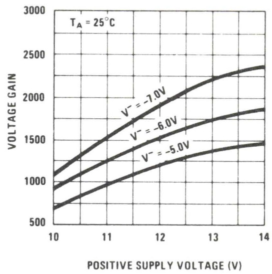
Transfer Function



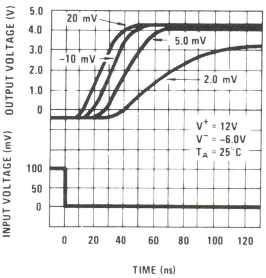
Voltage Gain



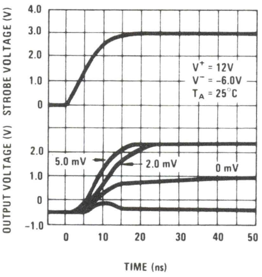
Voltage Gain



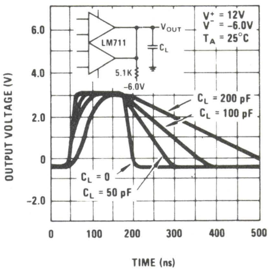
Response Time for Various Input Overdrives



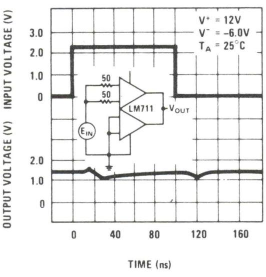
Strobe Release Time for Various Input Overdrives



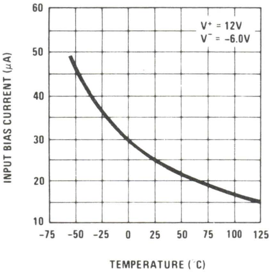
Output Pulse Stretching With Capacitive Loading



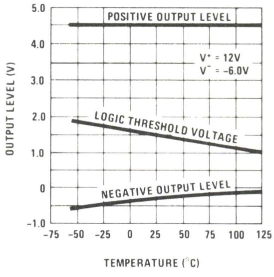
Common Mode Pulse Response



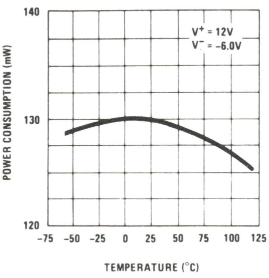
Input Bias Current



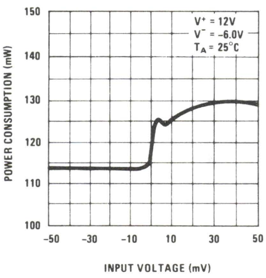
Output Voltage Level



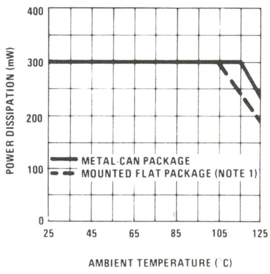
Power Consumption



Power Consumption



Maximum Power Dissipation



Voltage Comparators/Buffers

LM711C dual comparator

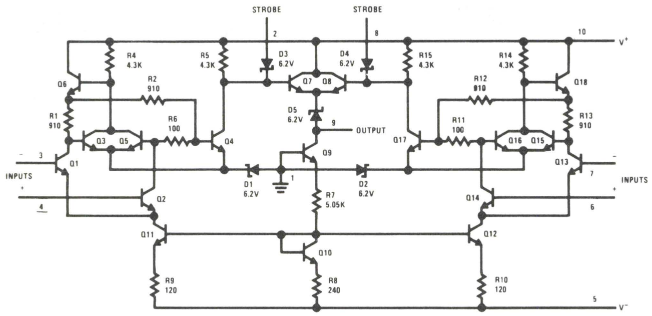
general description

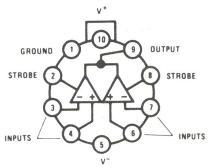
The LM711C contains two voltage comparators with separate differential inputs, a common output and provision for strobing each side independently. Similar to the LM710C, the device features low offset and thermal drift, a large input voltage range, low power consumption, fast recovery from large overloads and compatibility with most integrated logic circuits.

With the addition of an external resistor network, the LM711C can be used as a sense amplifier for core memories. The input thresholding, combined with the high gain of the comparator, eliminates many of the inaccuracies encountered with conventional sense amplifier designs. Further, it has the speed and accuracy needed for reliably detecting the outputs of cores as small as 20 mils.

The LM711C is also useful in other applications where a dual comparator with OR'ed outputs is required, such as a double-ended limit detector. By using common circuitry for both halves, the device can provide high speed with lower power dissipation than two single comparators. The LM711C is the commercial/industrial version of the LM711. It is identical to the LM711, except that operation is specified over a 0°C to 70°C temperature range.

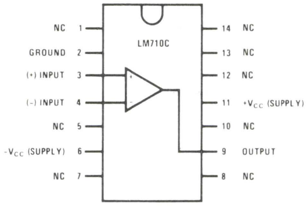
schematic** and connection diagrams





NOTE: Pin 5 connected to case

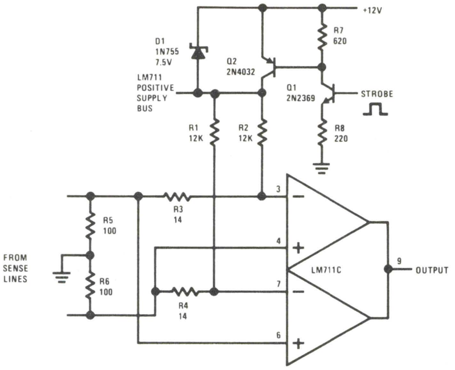
Order Number LM711CH
See Package 14



Order Number LM711CN
See Package 22

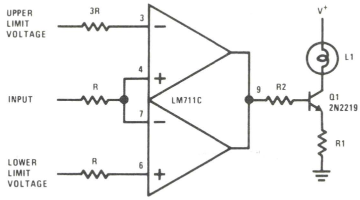
typical applications**

Sense Amplifier With Supply Strobing for Reduced Power Consumption*



*Standby dissipation is about 40 mW

Double-Ended Limit Detector With Lamp Driver



**Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	+14.0V
Negative Supply Voltage	-7.0V
Peak Output Current	25 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Strobe Voltage	0 to +6.0V
Internal Power Dissipation (Note 1)	300 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

(The following specfications apply for T_A = 25°C, V^+ = 12.0V, V^- = –6.0V unless otherwise specified)

PARAMETER	CONDITIONS (Note 2)	MIN.	TYP.	MAX.	UNIT
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$		1.0	5.0	mV
	$R_S \leq 200\Omega$, $-5V \leq V_{CM} \leq +5V$		1.0	7.5	mV
Input Offset Current			0.5	15	μA
Input Bias Current			25	100	μA
Voltage Gain		700	1500		
Response Time (Note 3)			40		ns
Strobe Release Time			12		ns
Input Voltage Range	$V^- = -7.0V$	±5.0			V
Differential Input Voltage Range		±5.0			V
Output Resistance			200		Ω
Positive Output Level	$V_{IN} \geq 10$ mV		4.5	5.0	V
Loaded Positive Output Level	$V_{IN} \geq 10$ mV, $I_{OUT} = -5$ mA	2.5	3.5		V
Negative Output Level	$V_{IN} \leq -10$ mV	–1.0	–0.5	0	V
Strobed Output Level	$V_{STROBE} \leq 0.3V$	–1.0		0	V
Output Sink Current	$V_{IN} \leq -10$ mV, $V_{OUT} \geq 0$	0.5	0.8		mA
Strobe Current	$V_{STROBE} = 100$ mV		1.2	2.5	mA
Positive Supply Current	$V_{IN} \leq -10$ mV		8.6		mA
Negative Supply Current			3.9		mA
Power Consumption			130	230	mW
The following specifications apply for 0°C $\leq T_A \leq$ +70°C:					
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$			6.0	mV
	$R_S \leq 200\Omega$, $-5V \leq V_{CM} \leq +5V$			10	mV
Input Offset Current				25	μA
Input Bias Current				150	μA
Average Temperature Coefficient of Input Offset Voltage			5.0		μV/°C
Voltage Gain		500			

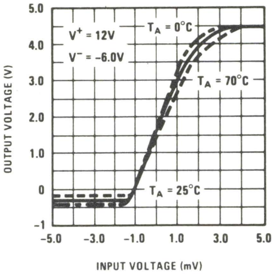
Note 1: Ratings apply for ambient temperatures to 70°C.

Note 2: The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.5V at 0°C, 1.4V at 25°C, and 1.2V at +70°C.

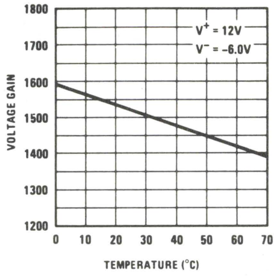
Note 3: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics

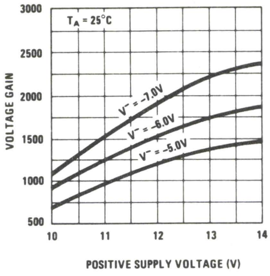
Transfer Function



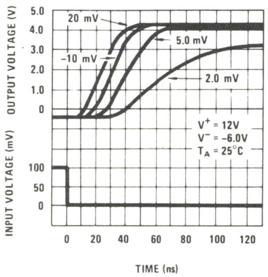
Voltage Gain



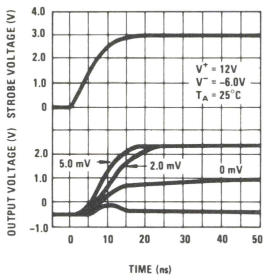
Voltage Gain



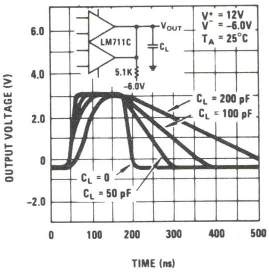
Response Time for Various Input Overdrives



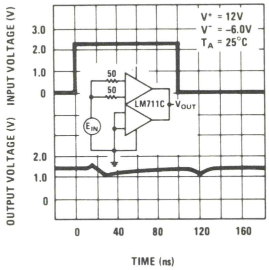
Strobe Release Time for Various Input Overdrives



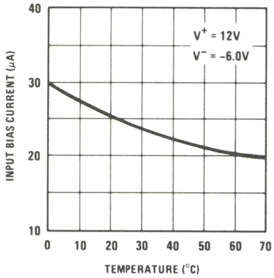
Output Pulse Stretching With Capacitive Loading



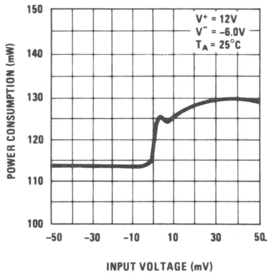
Common Mode Pulse Response



Input Bias Current



Power Consumption



Voltage Comparators/Buffers

LM1514/LM1414 dual differential voltage comparator

general description

The LM1514/LM1414 is a dual differential voltage comparator intended for applications requiring high accuracy and fast response times. The device is constructed on a single monolithic silicon chip.

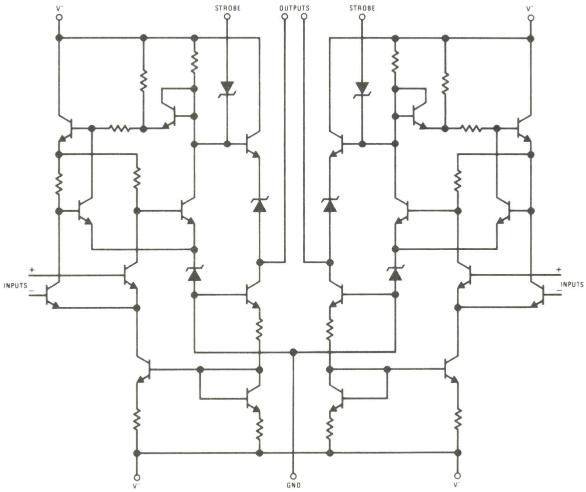
The LM1514/LM1414 is useful as a variable threshold Schmitt trigger, a pulse height discriminator, a voltage comparator in high-speed A-D converters, a memory sense amplifier or a high noise immunity line receiver. The output of the comparator is compatible with all integrated logic forms. The LM1514/LM1414 meet or exceed the specifications for the MC1514/MC1414 and are pin-for-pin replacements. The LM1514 is available in the ceramic dual-in-line package. The LM1414 is available in either the ceramic or molded dual-in-line package.

The LM1514 is specified for operation over the –55°C to +125°C military temperature range. The LM1414 is specified for operation over the 0°C to +70°C temperature range.

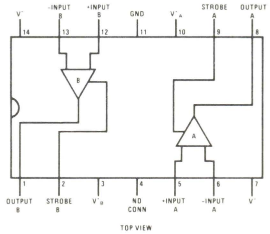
features

- Two totally separate comparators per package
- Independent strobe capability
- High speed 30 ns typ
- Low input offset voltage and current
- High output sink current over temperature
- Output compatible with TTL/DTL logic
- Molded or ceramic dual-in-line package

schematic and connection diagram



Dual-In-Line Package



Order Number LM1414J or LM1514J
See Package 16

Order Number LM1414N
See Package 22

absolute maximum ratings (Note 1)

Positive supply voltage	+14.0V
Negative supply voltage	-7.0V
Peak output current	10 mA
Differential input voltage	±5.0V
Input voltage	±7.0V
Power dissipation (Note 2)	600 mW
Operating temperature Range: LM1514	-55°C to $+125^\circ$C
LM1414	0°C to $+70^\circ$C
Storage temperature range	-65°C to $+150^\circ$C
Lead temperature (soldering, 10 sec)	300°C

electrical characteristics for $T_A = 25^\circ$C, $V^+ = +12$V, $V^- = -6$V, unless otherwise specified

PARAMETER	CONDITIONS	LM1514 MIN	LM1514 TYP	LM1514 MAX	LM1414 MIN	LM1414 TYP	LM1414 MAX	UNITS
Input Offset Voltage	$R_S \le 200\Omega$, $V_{CM} = 0$V, $V_{OUT} = 1.4$V		0.6	2.0		1.0	5.0	mV
Input Offset Current	$V_{CM} = 0$V, $V_{OUT} = 1.4$V		0.8	3.0		1.2	5.0	µA
Input Bias Current				20			25	µA
Voltage Gain		1250			1000			
Output Resistance			200			200		Ω
Differential Input Voltage Range		±5.0			±5.0			V
Input Voltage Range	$V^- = -7.0$V	±5.0			±5.0			V
Common Mode Rejection Ratio	$R_S \le 200\Omega$, $V^- = -7.0$V	80	100		70	100		dB
Positive Output Voltage	$V_{IN} \ge 7.0$ mV, $0 \le I_{OUT} \le -5.0$ mA	2.5	3.2	4.0	2.5	3.2	4.0	V
Negative Output Voltage	$V_{IN} \le -7.0$ mV	−1.0	−0.5	0	−1.0	−0.5	0	V
Strobed Output Voltage	$V_{STROBE} \le 0.3$V	−1.0	−0.5	0	−1.0	−0.5	0	V
Strobe "0" Current	$V_{STROBE} = 100$ mV		−1.2	−2.5		−1.2	−2.5	mA
Positive Supply Current	$V_{IN} \le -7$ mV			18			18	mA
Negative Supply Current	$V_{IN} \le -7$ mV			−14			−14	mA
Power Consumption			180	300		180	300	mW
Response Time	(Note 3)		30			30		ns
LM1514/LM1414: The following apply for $T_L \le T_A \le T_H$ (Note 4) unless otherwise specified								
Input Offset Voltage	$R_S \le 200\Omega$, $V_{OUT} = 1.8$V for $T_A = T_L$ $V_{CM} = 0$V, $V_{OUT} = 1.0$V for $T_A = T_H$			3.0 3.0			6.5 6.5	mV mV
Input Bias Current				45			40	µA
Temperature Coefficient of Input Offset Voltage			3.0			5.0		µV/°C
Input Offset Current	$V_{CM} = 0$V, $V_{OUT} = 1.8$V, $T_A = T_L$ $V_{CM} = 0$V, $V_{OUT} = 1.0$V, $T_A = T_H$			7.0 3.0			7.5 7.5	µA µA
Voltage Gain		1000			800			
Output Sink Current	$V_{IN} \le -9.0$ mV, $V_{OUT} \ge 0$V	2.8	4.0		1.6	2.5		mA

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: LM1514 ceramic package: The maximum junction temperature is $+150^\circ$C, for operating at elevated temperatures, devices must be derated linearly at 12.5 mW/°C. LM1414 ceramic package: The maximum junction temperature is $+95^\circ$C for operating at elevated temperatures, devices must be derated linearly at 12.5 mW/°C. LM1414 molded package: The maximum junction temperature is $+115^\circ$C, for operating at elevated temperatures, devices must be derated linearly at 6.7 mW/°C.

Note 3: The response time specified (see Definitions) for a 100 mV input step with 5 mV overdrive.

Note 4: For LM1514, $T_L = -55^\circ$C, $T_H = +125^\circ$C. For LM1414, $T_L = 0^\circ$C, $T_H = +70^\circ$C.

Functional Blocks

LM122/LM222/LM322 precision timer

general description

The LM122 is a precision timer that offers great versatility with high accuracy. It operates off unregulated supplies from 4.5V to 40V while maintaining constant timing periods from microseconds to hours. Internal logic and regulator circuits complement the basic timing function enabling the LM122 to operate in many different applications with a minimum of external components.

The output of the timer is a floating transistor with built in current limiting. It can drive either ground referred or supply referred loads up to 40V and 50 mA. The floating nature of this output makes it ideal for interfacing, lamp or relay driving, and signal conditioning where an open collector or emitter is required. A "logic reverse" circuit can be programmed by the user to make the output transistor either "on" or "off" during the timing period.

The trigger input to the LM122 has a threshold of 1.6V independent of supply voltage, but it is fully protected against inputs as high as ±40V – even when using a 5V supply. The circuitry reacts only to the rising edge of the trigger signal, and is immune to any trigger voltage during the timing periods.

An internal 3.15V regulator is included in the timer to reject supply voltage changes and to provide the user with a convenient reference for applications other than a basic timer. External loads up to 5 mA can be driven by the regulator. An internal 2V divider between the reference and ground sets the timing period to 1 RC. The timing period can be voltage controlled by driving this divider with an external source through the V_{ADJ} pin. Timing ratios of 50:1 can be easily achieved.

The comparator used in the LM122 utilizes high gain PNP input transistors to achieve 300 pA typical input bias current over a common mode range of 0V to 3V. A boost terminal allows the user to increase comparator operating current for timing periods less than 1 ms. This lets the timer operate over a 3μs to multi-hour timing range with excellent repeatability.

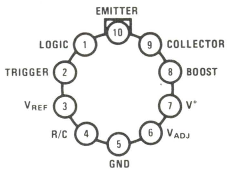
The LM122 operates over a temperature range of −55°C to +125°C. An electrically identical LM222 is specified from −25°C to +85°C. The timer is available in TO-5, flat package, and dual-in-line packages.

features

- Immune to changes in trigger voltage during timing interval
- Timing periods from microseconds to hours
- Internal logic reversal
- Immune to power supply ripple or noise during the timing interval
- Operates from 4.5V to 40V supplies
- Input protected to ±40V
- Floating transistor output with internal current limiting
- Internal regulated reference
- Timing period can be voltage controlled
- TTL compatible input and output

connection diagrams

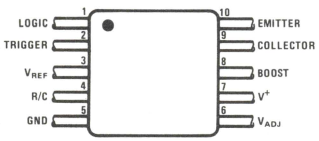
Metal Can Package



TOP VIEW

Order Number LM122H, LM222H or LM322H
See Package 14

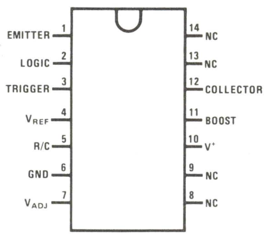
Flat Package



TOP VIEW

Order Number LM122F
See Package 3

Dual-In-Line Package



TOP VIEW

Order Number LM322N
See Package 22

absolute maximum ratings

Power Dissipation	500 mW
V^+ Voltage	40V
Collector Output Voltage	40V
V_{REF} Current	5 mA
Trigger Voltage	±40V
V_{ADJ} Voltage (Forced)	5V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM122/LM222 electrical characteristics (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	$T_A = 25°C$, $4.5V \le V^+ \le 40V$ Boost Tied to V^+	.626 .620	.632 .632	.638 .644	
Comparator Input Current	$T_A = 25°C$, $4.5V \le V^+ \le 40V$ Boost Tied to V^+		.3 30	1 100	nA nA
Trigger Voltage	$T_A = 25°C$, $4.5V \le V^+ \le 40V$	1.2	1.6	2	V
Trigger Current	$T_A = 25°C$, $V_{TRIG} = 2V$		25		μA
Supply Current	$T_A = 25°C$, $4.5V \le V^+ \le 40V$		2.5	4	mA
Timing Ratio	$4.5V \le V^+ \le 40V$ Boost Tied to V^+	.620 .620		.644 .644	
Comparator Input Current (Note 4)	$4.5V \le V^+ \le 40V$ Boost Tied to V^+	−5		5 100	nA nA
Trigger Voltage	$4.5V \le V^+ \le 40V$	.8		2.5	V
Trigger Current	$V_{TRIG} = 2.5V$			100	μA
Output Leakage Current	$V_{CE} = 40V$			1	μA
Capacitor Saturation Voltage	$R_t \ge 1\ M\Omega$ $R_t = 10\ k\Omega$		2.5 25		mV mV
Reset Resistance			150		Ω
Reference Voltage	$T_A = 25°C$	3	3.15	3.3	V
Reference Regulation	$0 \le I_{OUT} \le 3\ mA$ $4.5V \le V^+ < 40V$		20 6	50 25	mV mV
Collector Saturation Voltage	$I_L = 8\ mA$ $I_L = 50\ mA$		.25 .7	.4 1.4	V V
Emitter Saturation Voltage	$I_L = 3\ mA$ $T_A = 25°C$ $I_L = 50\ mA$		1.8 2.1	2.2 3	V V
Average Temperature Coefficient of Timing Ratio				.003	%/°C
Minimum Trigger Width	$V_{TRIG} = 2.5V$		.25		μs

Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = 120/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

Note 2: Specifications include the temperature range, $-55°C \le T_A \le +125°C$ for the LM122 and $-25°C \le T_A \le +85°C$ for the LM222.

Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_t)[1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_t)$ for all but the most critical applications.

Note 4: Sign reversal may occur at high temperatures (> 100°C) where comparator input current is predominately leakage. See typical curves.

absolute maximum ratings

Power Dissipation	500 mW
V^+ Voltage	40V
Collector Output Voltage	40V
V_{REF} Current	5 mA
Trigger Voltage	±40V
V_{ADJ} Voltage (Forced)	5V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM322
electrical characteristics (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	$T_A = 25°C$, $4.5V \le V^+ \le 40V$ Boost Tied to V^+	.620 .620	.632 .632	.644 .644	
Comparator Input Current	$T_A = 25°C$, $4.5V \le V^+ \le 40V$ Boost Tied to V^+		.3 30	1 100	nA nA
Trigger Voltage	$T_A = 25°C$, $4.5V \le V^+ \le 40V$	1.2	1.6	2	V
Trigger Current	$T_A = 25°C$, $V_{TRIG} = 2V$		25		μA
Supply Current	$T_A = 25°C$, $4.5V \le V^+ \le 40V$		2.5	4.5	mA
Timing Ratio	$4.5V \le V^+ \le 40V$ Boost Tied to V^+	.610 .610		.654 .654	
Comparator Input Current (Note 4)	$4.5V \le V^+ \le 40V$ Boost Tied to V^+	−2		2 150	nA nA
Trigger Voltage	$4.5V \le V^+ \le 40V$	.8		2.5	V
Trigger Current	$V_{TRIG} = 2.5V$			200	μA
Output Leakage Current	$V_{CE} = 40V$			5	μA
Capacitor Saturation Voltage	$R_t \ge 1\ M\Omega$ $R_t = 10\ k\Omega$		2.5 25		mV mV
Reset Resistance			150		Ω
Reference Voltage	$T_A = 25°C$	3	3.15	3.3	V
Reference Regulation	$0 \le I_{OUT} \le 3\ mA$ $4.5V \le V^+ < 40V$		20 6	50 25	mV mV
Collector Saturation Voltage	$I_L = 8\ mA$ $I_L = 50\ mA$		.25 .7	.4 1.4	V V
Emitter Saturation Voltage	$I_L = 3\ mA$ $T_A = 25°C$ $I_L = 50\ mA$		1.8 2.1	2.2 3	V V
Average Temperature Coefficient of Timing Ratio				.003	%/°C
Minimum Trigger Width	$V_{TRIG} = 2.5V$		.25		μs

Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = .120/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

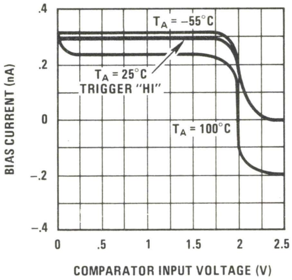
Note 2: Specifications include the temperature range 0°C to +70°C for the LM322 unless otherwise noted.

Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_t)[1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_t)$ for all but the most critical applications.

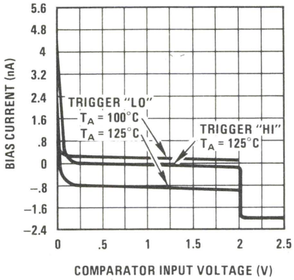
Note 4: Sign reversal may occur at high temperatures (> 70°C) where comparator input current is predominately leakage. See typical curves.

typical performance characteristics

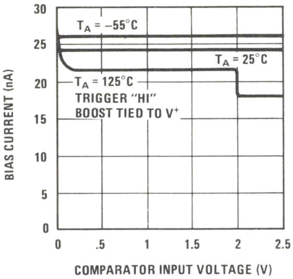
Comparator Bias Current



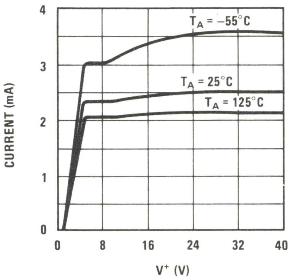
Comparator Bias Current



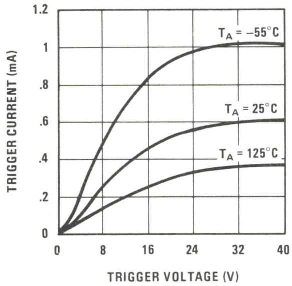
Comparator Bias Current



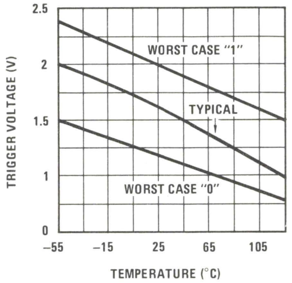
Supply Current



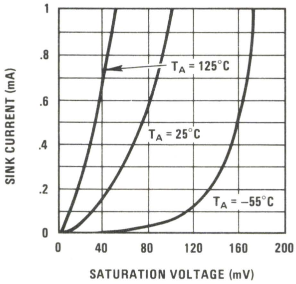
Trigger Input Characteristics



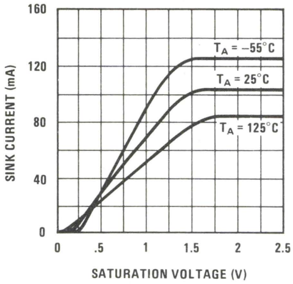
Trigger Threshold



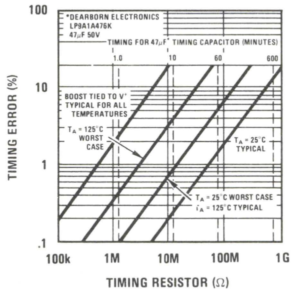
Output Transistor Saturation Characteristics at Low Currents



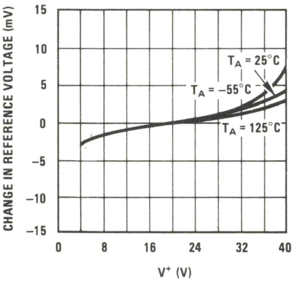
Collector Output Saturation Characteristics at High Current



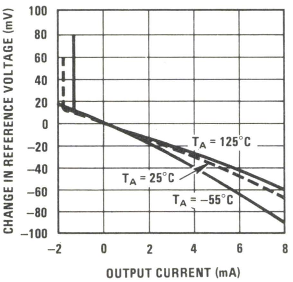
Timing Error Due to Comparator Bias Current



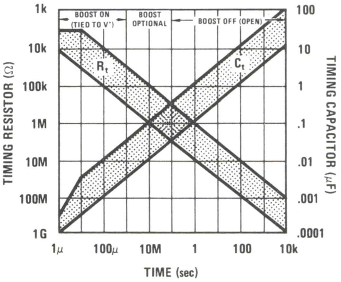
Reference Regulation



Reference Regulation

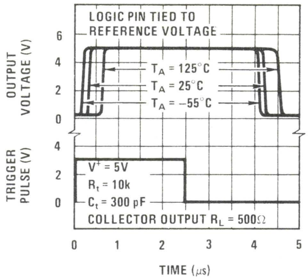


Suggested Timing Components

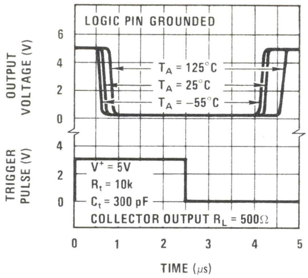


typical performance characteristics (con't)

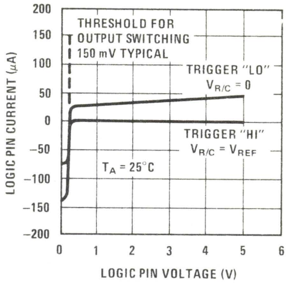
Short Output Pulse



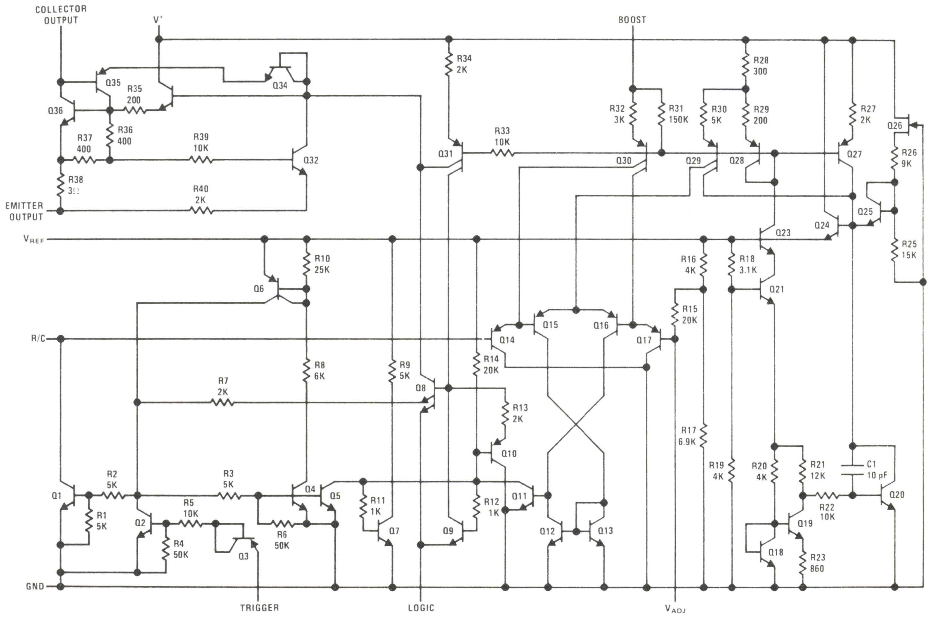
Short Output Pulse



Logic Pin Characteristics

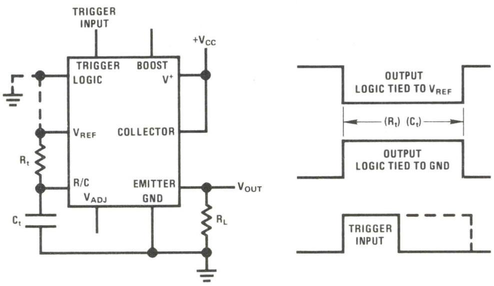


schematic diagram

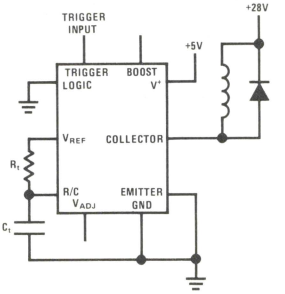


4

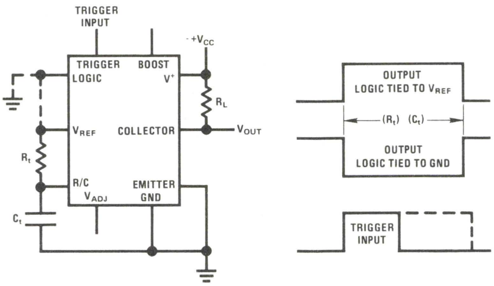
typical applications



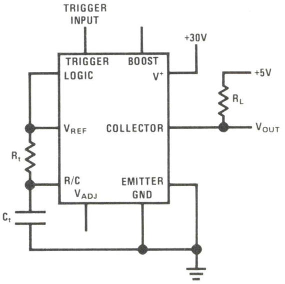
Basic Timer-Emitter Output and Timing Chart



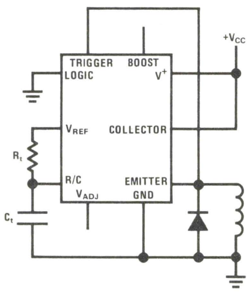
5V Logic Supply Driving 28V Relay



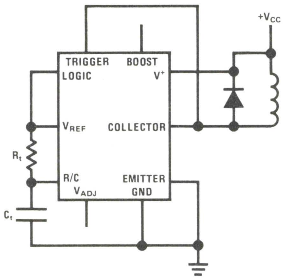
Basic Timer-Collector Output and Timing Chart



30V Supply Interfacing to 5V Logic

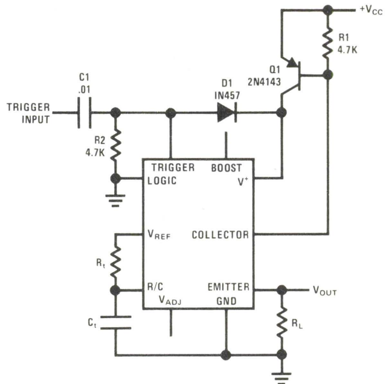


Time Out On Power Up
Relay Energized Until R_t C_t Seconds After V_{CC} is Applied

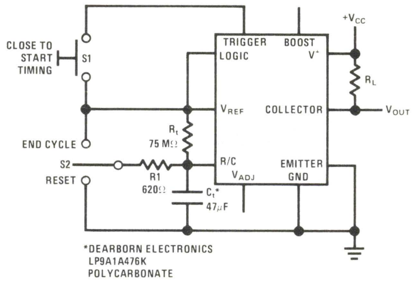


Time Out On Power Up
Relay Energized R_t C_t Seconds After V_{CC} is Applied

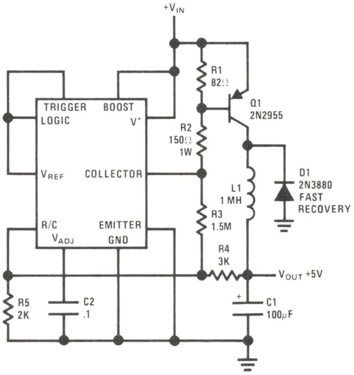
typical applications (con't)



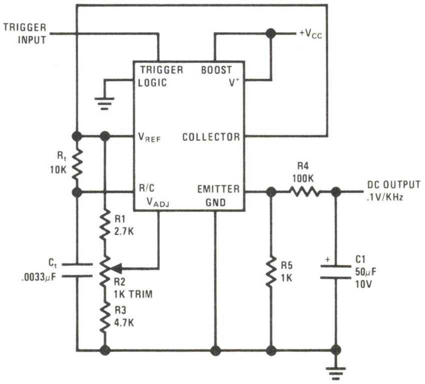
Zero Power Dissipation Between Timing Intervals



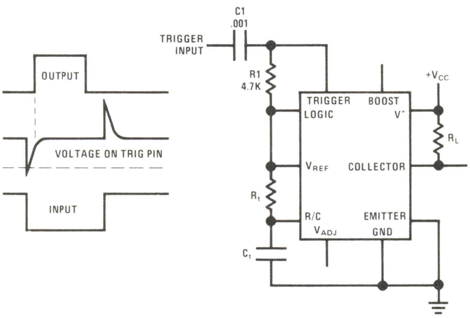
One Hour Timer with Reset & Manual Cycle End



5V Switching Regulator with 1 Amp
Output and 5.5V Minimum Input

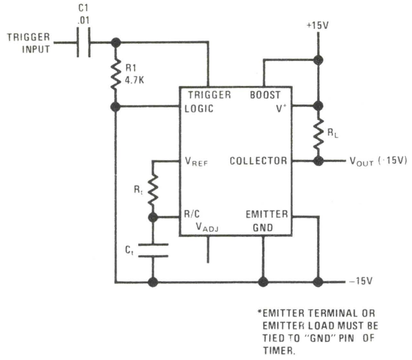


Frequency to Voltage Converter (Tachometer)
Output Independent of Supply Voltage

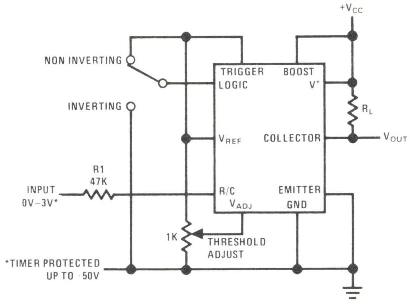


Timer Triggered by Negative Edge of Input Pulse

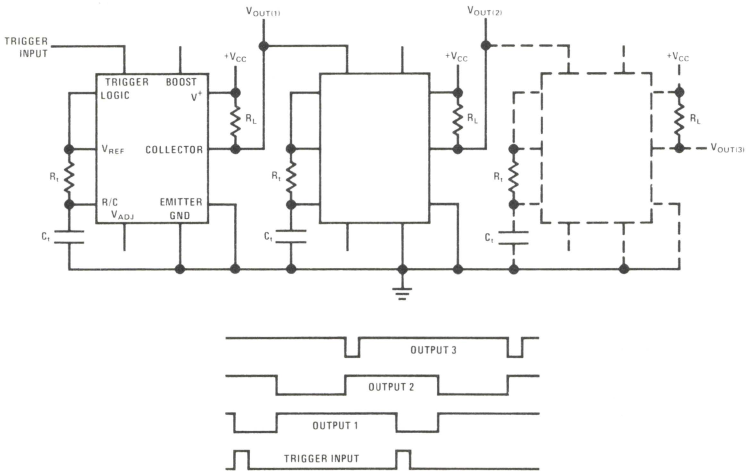
typical applications (con't)



Operating off ±15V Supplies*



Comparator with 0V to 3V Threshold



Chain of Timers and Timing Chart

Functional Blocks

LM555/LM555C timer

general description

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For astable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits.

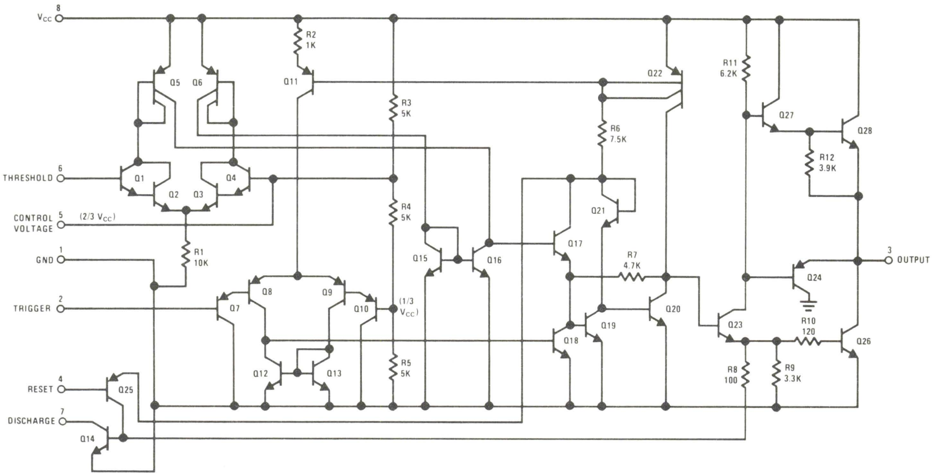
features

- Direct replacement for SE555/NE555
- Timing from microseconds through hours
- Operates in both astable and monostable modes
- Adjustable duty cycle
- Output can source or sink 200mA
- Output and supply TTL compatible
- Temperature stability better than .005% per °C
- Normally on and normally off output

applications

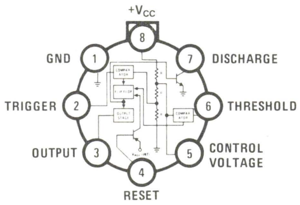
- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation
- Pulse position modulation
- Linear ramp generator

schematic diagram



connection diagrams

Metal Can Package

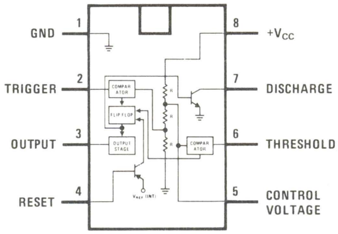


TOP VIEW

Order Number LM555H or LM555CH

See Package 11

Dual-In-Line Package



TOP VIEW

Order Number LM555CN

See Package 20

absolute maximum ratings

Supply Voltage	+18V
Power Dissipation	600 mW
Operating Temperature Ranges	
LM555C	0°C to +70°C
LM555	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V_{CC} = +5V to +15V unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM555			LM555C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Supply Voltage		4.5		18	4.5		16	V
Supply Current	V_{CC} = 5V, R_L = ∞		3	5		3	6	mA
	V_{CC} = 15V, R_L = ∞ (Low State) (Note 1)		10	12		10	15	mA
Timing Error, Monostable								
Initial Accuracy	R_A, R_B = 1k to 100k, C = .1μF, (Note 2)		.5	2		1		%
Drift with Temperature			30	100		50		ppm/°C
Drift with Supply			.005	.02		.01		%/V
Threshold Voltage			.667			.667		x V_{CC}
Trigger Voltage	V_{CC} = 15V	4.8	5	5.2		5		V
	V_{CC} = 5V	1.45	1.67	1.9		1.67		V
Trigger Current			.5			.5		μA
Reset Voltage		.4	.7	1	.4	.7	1	V
Reset Current			.1			.1		mA
Threshold Current	(Note 3)		.1	.25		.1	.25	μA
Control Voltage Level	V_{CC} = 15V	9.6	10	10.4	9	10	11	V
	V_{CC} = 5V	2.9	3.33	3.8	2.6	3.33	4	V
Output Voltage Drop (Low)	V_{CC} = 15V							
	I_{SINK} = 10 mA		.1	.15		.1	.25	V
	I_{SINK} = 50 mA		.4	.5		.4	.75	V
	I_{SINK} = 100 mA		2	2.2		2	2.5	V
	I_{SINK} = 200 mA		2.5			2.5		V
	V_{CC} = 5V							
	I_{SINK} = 8 mA		.1	.25				V
	I_{SINK} = 5 mA					.25	.35	V
Output Voltage Drop (High)	I_{SOURCE} = 200 mA, V_{CC} = 15V		12.5			12.5		V
	I_{SOURCE} = 100 mA, V_{CC} = 15V	13	13.3		12.75	13.3		V
	V_{CC} = 5V	3	3.3		2.75	3.3		V
Rise Time of Output			100			100		ns
Fall Time of Output			100			100		ns

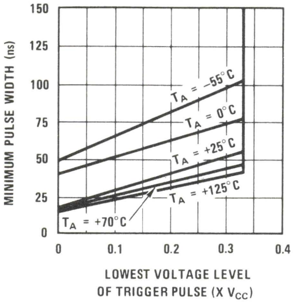
Note 1: Supply current when output high typically 1 mA less at V_{CC} = 5V.

Note 2: Tested at V_{CC} = 5V and V_{CC} = 15V.

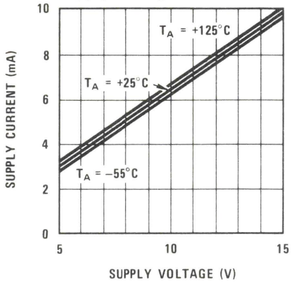
Note 3: This will determine the maximum value of $R_A + R_B$ for 15V operation. The max total $(R_A + R_B)$ = 20 MΩ.

typical performance characteristics

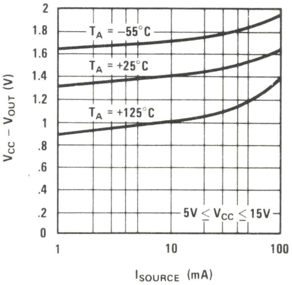
Minimum Pulse Width Required for Triggering



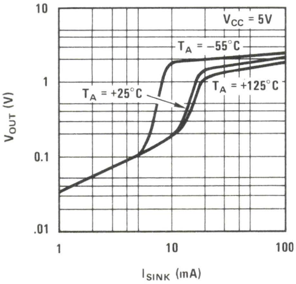
Supply Current vs Supply Voltage



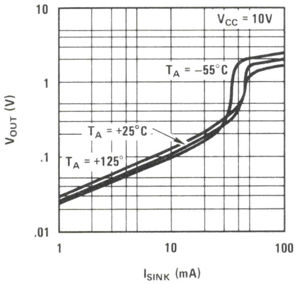
High Output Voltage vs Output Source Current



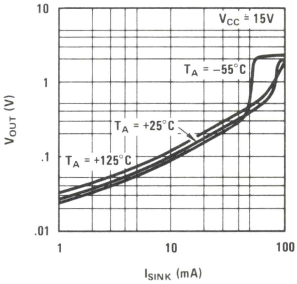
Low Output Voltage vs Output Sink Current



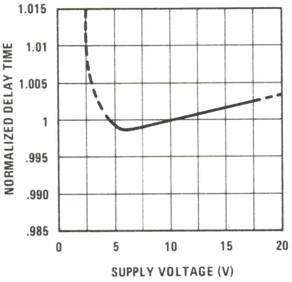
Low Output Voltage vs Output Sink Current



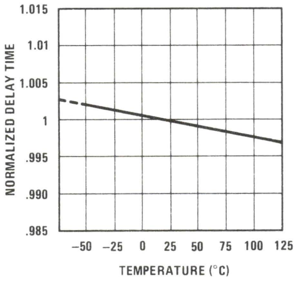
Low Output Voltage vs Output Sink Current



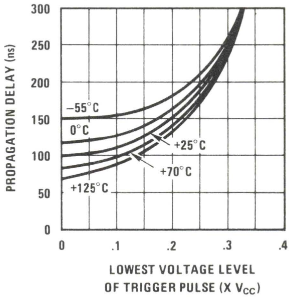
Delay Time vs Supply Voltage



Delay Time vs Temperature



Propagation Delay vs Voltage Level of Trigger Pulse



applications information

MONOSTABLE OPERATION

In this mode of operation, the timer functions as a one-shot (Figure 1). The external capacitor is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse of less than 1/3 V_{CC} to pin 2, the flip flop is set which both releases the short circuit across the capacitor and drives the output high. The voltage

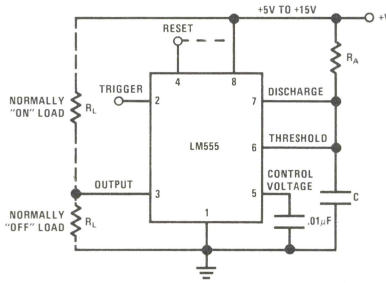
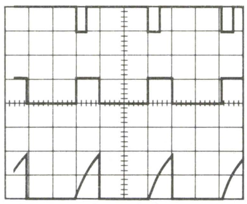


FIGURE 1. Monostable

across the capacitor then increases exponentially for a period of $t = 1.1\ R_A C$, at the end of which time the voltage equals 2/3 V_{CC}. The comparator then resets the flip flop which in turn discharges the capacitor and drives the output to its low state. Figure 2 shows the waveforms generated in this mode of operation. Since the charge and the threshold level of the comparator are both directly proportional to supply voltage, the timing internal is independent of supply.



V_{CC} = 5V
TIME = 0.1 ms/DIV.
R_A = 9.1 kΩ
C = .01μF

TOP TRACE: INPUT 5V/DIV.
MIDDLE TRACE: OUTPUT 5V/DIV.
BOTTOM TRACE: CAPACITOR VOLTAGE 2V/DIV.

FIGURE 2. Monostable Waveforms

During the timing cycle when the output is high, the further application of a trigger pulse will not effect the circuit. However the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied.

When the reset function is not in use, it is recommended that it be connected to V_{CC} to avoid any possibility of false triggering.

Figure 3 is a nomograph for easy determination of R, C values for various time delays.

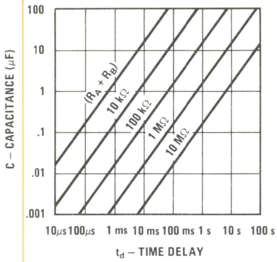


FIGURE 3. Time Delay

ASTABLE OPERATION

If the circuit is connected as shown in Figure 4 (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through $R_A + R_B$ and discharges through R_B. Thus the duty cycle may be precisely set by the ratio of these two resistors.

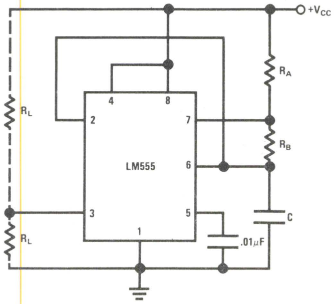
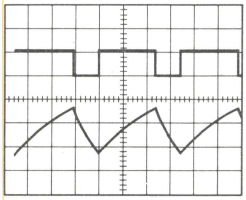


FIGURE 4. Astable

In this mode of operation, the capacitor charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times, and therefore the frequency are independent of the supply voltage.



V_{CC} = 5V
TIME = 20μs/DIV.
R_A = 3.9 kΩ
R_B = 3 kΩ
C = .01μF

TOP TRACE: OUTPUT 5V/DIV.
BOTTOM TRACE: CAPACITOR VOLTAGE 1V/DIV.

FIGURE 5. Astable Waveforms

Figure 5 shows the waveforms generated in this mode of operation.

applications information (con't)

The charge time (output high) is given by:

$$t_1 = 0.693\ (R_A + R_B)\ C$$

And the discharge time (output low) by:

$$t_2 = 0.693\ (R_B)\ C$$

Thus the total period is:

$$T = t_1 + t_2 = 0.693\ (R_A + 2R_B)\ C$$

The frequency of oscillation is:

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2\ R_B)\ C}$$

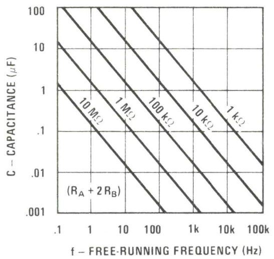


FIGURE 6. Free Running Frequency

Figure 6 may be used for quick determination of these RC values.

The duty cycle is: $D = \dfrac{R_B}{R_A + 2R_B}$

FREQUENCY DIVIDER

The monostable circuit of Figure 1 can be used as a frequency divider by adjusting the length of the timing cycle. Figure 7 shows the waveforms generated in a divide by three circuit.

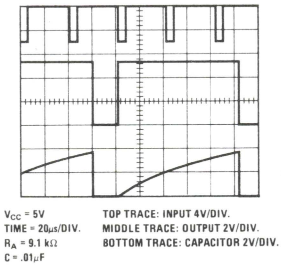


FIGURE 7. Frequency Divider

PULSE WIDTH MODULATOR

When the timer is connected in the monostable mode and triggered with a continuous pulse train, the output pulse width can be modulated by a signal applied to pin 5. Figure 8 shows the circuit, and in Figure 9 are some waveform examples.

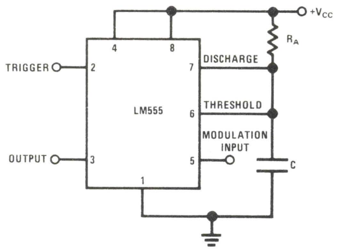


FIGURE 8. Pulse Width Modulator

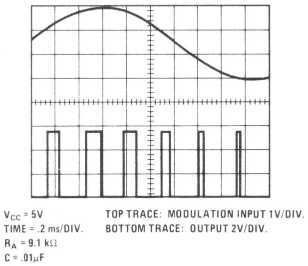


FIGURE 9. Pulse Width Modulator

PULSE POSITION MODULATOR

This application uses the timer connected for astable operation, as in Figure 10, with a modulating signal again applied to the control voltage terminal. The pulse position varies with the modulating signal, since the threshold voltage and hence

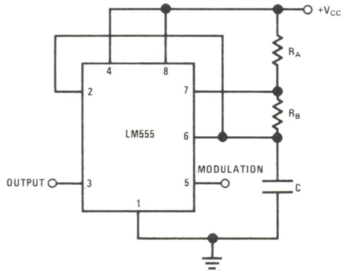


FIGURE 10. Pulse Position Modulator

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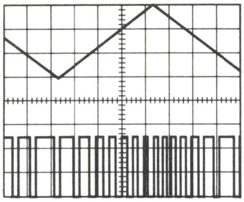
applications information (con't)

the time delay is varied. Figure 11 shows the waveforms generated for a triangle wave modulation signal.



V_{CC} = 5V
TIME = .1 ms/DIV.
R_A = 3.9 kΩ
R_B = 3 kΩ
C = .01μF

TOP TRACE: MODULATION 1V/DIV.
BOTTOM TRACE: OUTPUT 2V/DIV.

FIGURE 11. Pulse Position Modulator

LINEAR RAMP

When the pullup resistor, R_A, in the monostable circuit is replaced by a constant current source, a

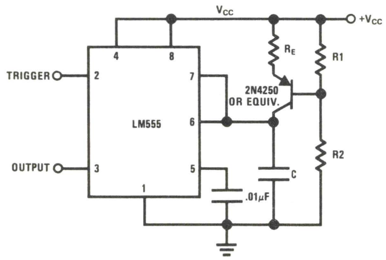


FIGURE 12.

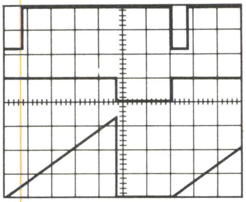
linear ramp is generated. Figure 12 shows a circuit configuration that will perform this function.

Figure 13 shows waveforms generated by the linear ramp.

The time interval is given by:

$$T = \frac{2/3\ V_{CC}\ R_E\ (R_1 + R_2)\ C}{R_1\ V_{CC} - V_{DE}\ (R_1 + R_2)}$$

$$V_{BE} \simeq 0.6V$$



V_{CC} = 5V
TIME = 20μs/DIV.
R_1 = 47 kΩ
R_2 = 100 kΩ
R_E = 2.7 kΩ
C = .01μF

TOP TRACE: INPUT 3V/DIV.
MIDDLE TRACE: OUTPUT 5V/DIV.
BOTTOM TRACE: CAPACITOR VOLTAGE 1V/DIV.

FIGURE 13. Linear Ramp

50% DUTY CYCLE OSCILLATOR

For a 50% duty cycle, the resistors R_A and R_B may be connected as in Figure 14. The time period for the output positive is the same as previous,

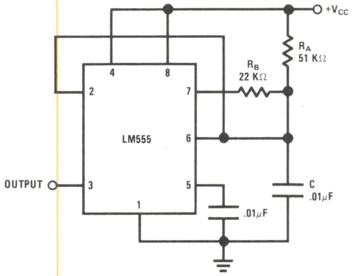


FIGURE 14. 50% Duty Cycle Oscillator

$t_1 = .693\ R_A\ C$. For the output negative it is $t_2 =$

$$[(R_A\ R_B)/(R_A + R_B)]\ CLn \left[\frac{R_B - 2R_A}{2R_B - R_A}\right]$$

Thus the frequency of oscillation is $f = \dfrac{1}{t_1 + t_2}$

Note that this circuit will not oscillate if R_B is greater than 1/2 R_A because the junction of R_A and R_B cannot bring pin 2 down to 1/3 V_{CC} and trigger the lower comparator.

Functional Blocks

LM2905/LM3905 precision timer

general description

The LM3905 is a precision timer that offers great versatility with high accuracy. It operates off unregulated supplies from 4.5V to 40V while maintaining constant timing periods from milliseconds to hours. Internal logic and regulator circuits complement the basic timing function enabling the LM3905 to operate in many different applications with a minimum of external components.

The output of the timer is a floating transistor with built in current limiting. It can drive either ground referred or supply referred loads up to 40V and 50 mA. The floating nature of this output makes it ideal for interfacing, lamp or relay driving, and signal conditioning where an open collector or emitter is required. A "logic reverse" circuit can be programmed by the user to make the output transistor either "on" or "off" during the timing period.

The trigger input to the LM3905 has a threshold of 1.6V independent of supply voltage, but it is fully protected against inputs as high as ±40V – even when using a 5V supply. The circuitry reacts only to the rising edge of the trigger signal, and is immune to any trigger voltage during the timing periods.

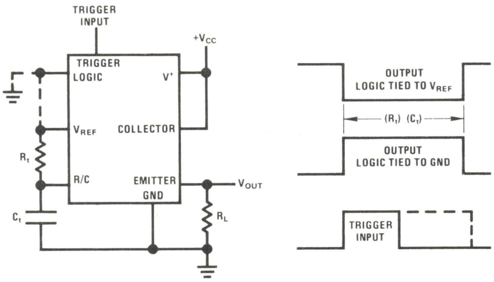
An internal 3.15V regulator is included in the timer to reject supply voltage changes and to provide the user with a convenient reference for applications other than a basic timer. External loads up to 5 mA can be driven by the regulator. An internal 2V divider between the reference and ground sets the timing period to 1 RC.

The comparator used in the LM3905 utilizes high gain PNP input transistors to achieve 300 pA typical input bias current over a common mode range of 0V to 3V.

features

- Immune to changes in trigger voltage during timing interval
- Timing periods from milliseconds to hours
- Internal logic reversal
- Immune to power supply ripple or noise during the timing interval
- Operates from 4.5V to 40V supplies
- Input protected to ±40V
- Floating transistor output with internal current limiting
- Internal regulated reference
- TTL compatible input and output

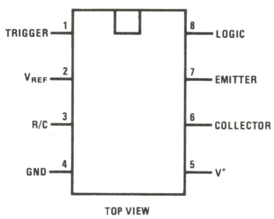
typical applications



Basic Timer-Emitter Output and Timing Chart

connection diagram

Dual-In-Line Package



Order Number LM2905N or LM3905N
See Package 20

absolute maximum ratings

Power Dissipation	500 mW
V^+ Voltage	40V
Collector Output Voltage	40V
V_{REF} Current	5 mA
Trigger Voltage	±40V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM2905/LM3905 electrical characteristics (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	$T_A = 25°C, 4.5V \leq V^+ \leq 40V$	.620	.632	.644	
Comparator Input Current	$T_A = 25°C, 4.5V \leq V^+ \leq 40V$		.3	1	nA
Trigger Voltage	$T_A = 25°C, 4.5V \leq V^+ \leq 40V$	1.2	1.6	2	V
Trigger Current	$T_A = 25°C, V_{TRIG} = 2V$		25		μA
Supply Current	$T_A = 25°C, 4.5V \leq V^+ \leq 40V$		2.5	4.5	mA
Timing Ratio	$4.5V \leq V^+ \leq 40V$	.610		.654	
Comparator Input Current (Note 4)	$4.5V \leq V^+ \leq 40V$	−2		2	nA
Trigger Voltage	$4.5V \leq V^+ \leq 40V$	.8		2.5	V
Trigger Current	$V_{TRIG} = 2.5V$			200	μA
Output Leakage Current	$V_{CE} = 40V$			5	μA
Capacitor Saturation Voltage	$R_t \geq 1\ M\Omega$ $R_t = 10\ k\Omega$		2.5 25		mV mV
Reset Resistance			150		Ω
Reference Voltage	$T_A = 25°C$	3	3.15	3.3	V
Reference Regulation	$0 \leq I_{OUT} \leq 3\ mA$ $4.5V \leq V^+ \leq 40V$		20 6	50 25	mV mV
Collector Saturation Voltage	$I_L = 8\ mA$ $I_L = 50\ mA$		.25 .7	.4 1.4	V V
Emitter Saturation Voltage	$I_L = 3\ mA$ $I_L = 50\ mA$		1.8 2.1	2.2 3	V V
Average Temperature Coefficient of Timing Ratio				.003	%/°C
Minimum Trigger Width	$V_{TRIG} = 2.5V$		.25		μs

Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = 50/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

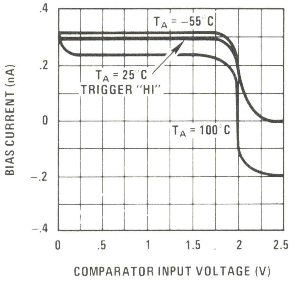
Note 2: Specifications include the temperature range $-40°C \leq T_A \leq +85°C$ for the LM2905 and $0°C \leq T_A \leq +70°C$ for the LM3905 unless otherwise noted.

Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_r)[1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_t)$ for all but the most critical applications.

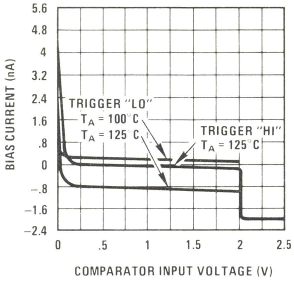
Note 4: Sign reversal may occur at high temperatures (> 70°C) where comparator input current is predominately leakage. See typical curves.

typical performance characteristics

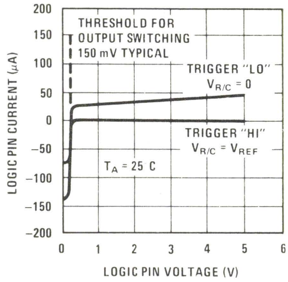
Comparator Bias Current



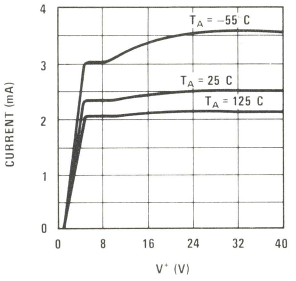
Comparator Bias Current



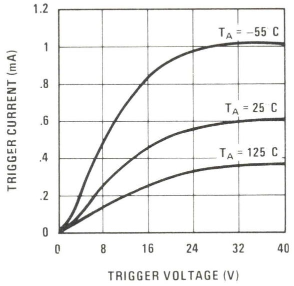
Logic Pin Characteristics



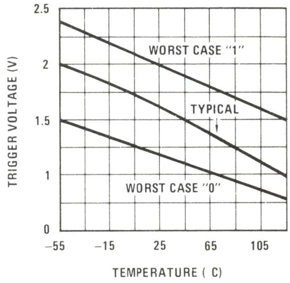
Supply Current



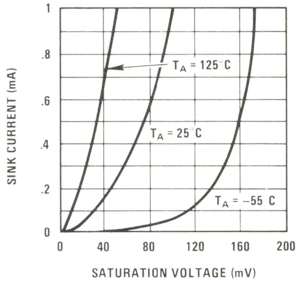
Trigger Input Characteristics



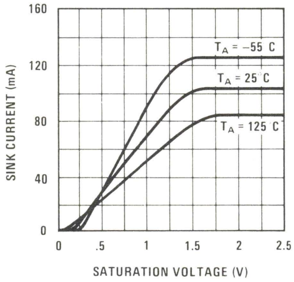
Trigger Threshold



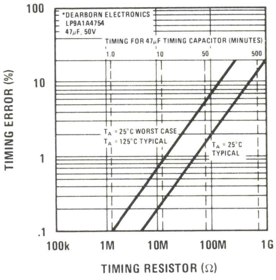
Output Transistor Saturation Characteristics at Low Currents



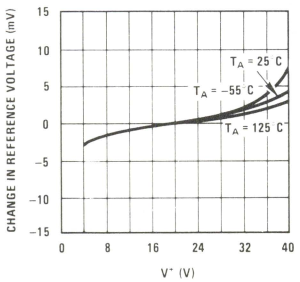
Collector Output Saturation Characteristics at High Current



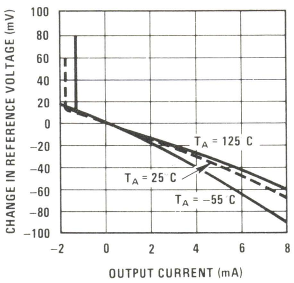
Timing Error Due to Comparator Bias Current



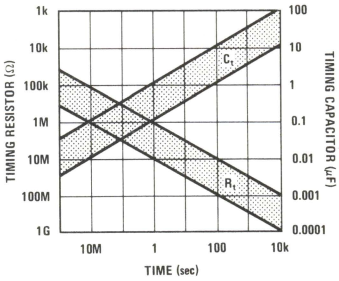
Reference Regulation



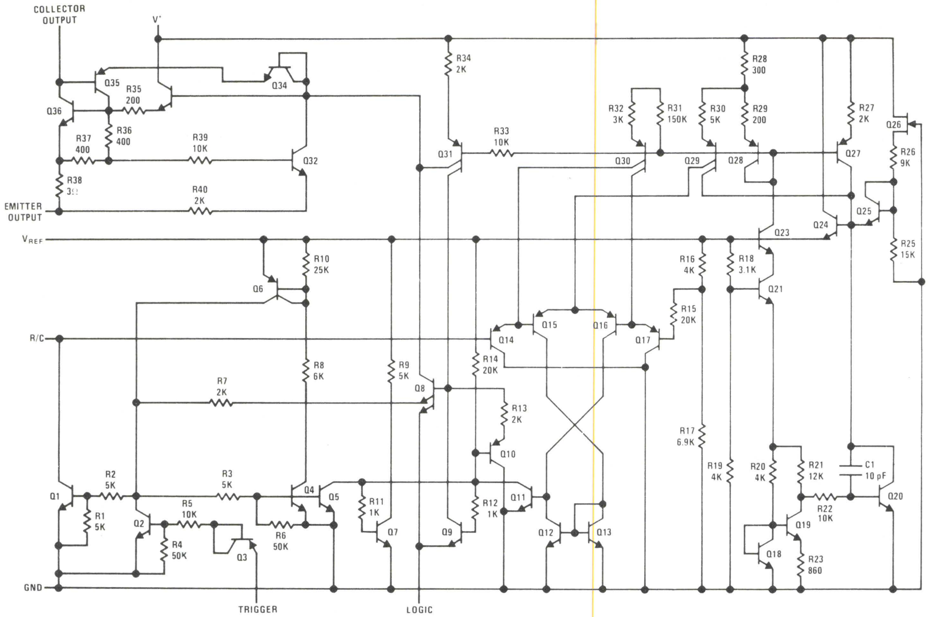
Reference Regulation



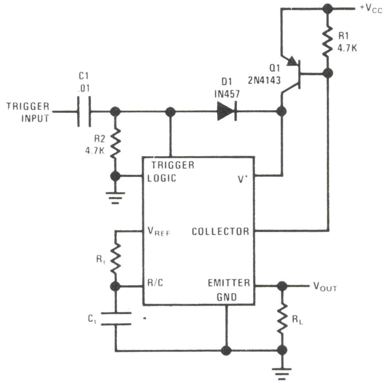
Suggested Timing Components



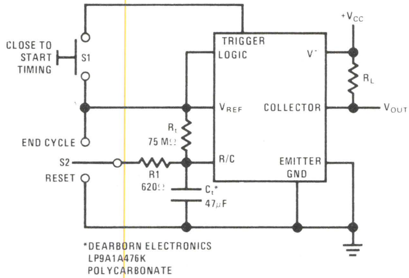
schematic diagram



typical applications(con't)

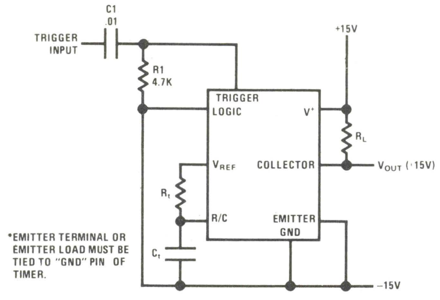


Zero Power Dissipation Between Timing Intervals

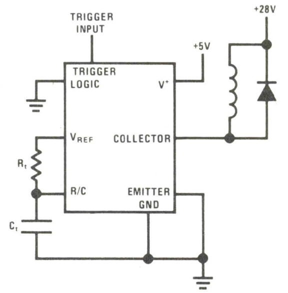


One Hour Timer with Reset & Manual Cycle End

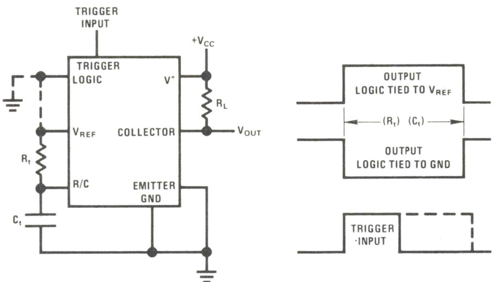
typical applications (con't)



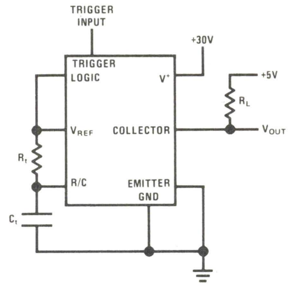
Operating off ±15V Supplies*



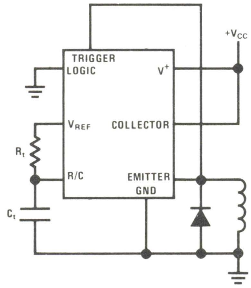
5V Logic Supply Driving 28V Relay



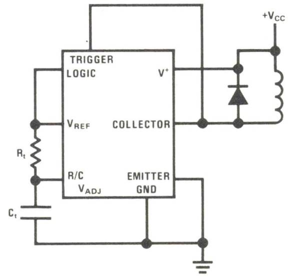
Basic Timer-Collector Output and Timing Chart



30V Supply Interfacing to 5V Logic

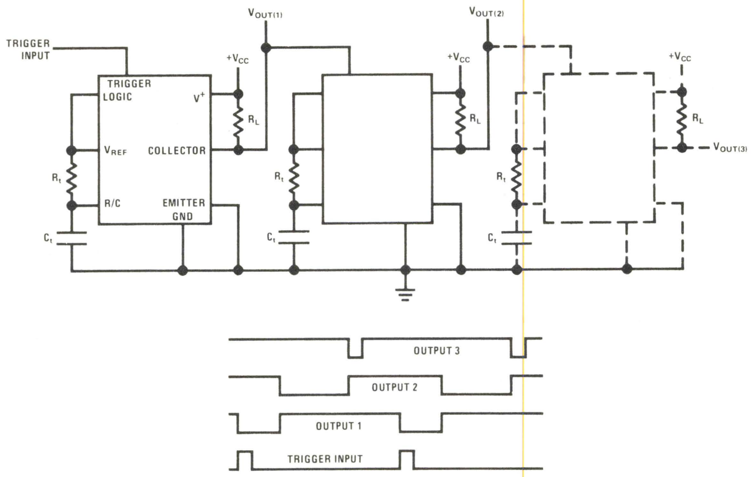


Time Out On Power Up
Relay Energized Until R_t C_t Seconds After V_{CC} is Applied

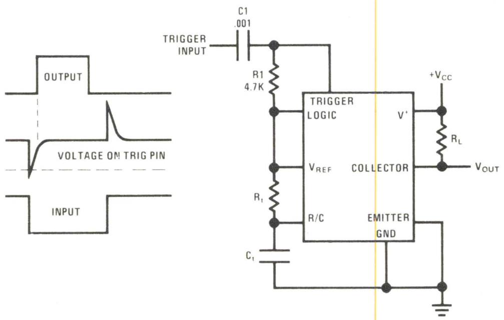


Time Out On Power Up
Relay Energized R_t C_t Seconds After V_{CC} is Applied

typical applications (con't)



Chain of Timers and Timing Chart



Timer Triggered by Negative Edge of Input Pulse

Functional Blocks

LX1600A absolute pressure transducer

general description

The LX1600A is a highly accurate, completely field interchangeable, temperature compensated, absolute pressure transducer. It contains in one small package all four of the basic transduction elements shown below in the block diagram – diaphragm and vacuum reference, piezoresistive sensor, signal discriminator and conditioner, and signal amplifier and processor. The first three elements are contained in one single silicon die and the fourth is provided by various standard National linear integrated circuit operational amplifiers.

By applying automatic laser trimming techniques, the output of each LX1600A is factory adjusted so that it meets the nominal values within the specified tolerances. This eliminates the need for user evaluation and calibration – **for each unit the specified nominal output is the "best straight line actual" value.**

The particular design chosen leads to an equivalent circuit for the LX1600A that can be described as a simple potentiometer without a potentiometer's loading problems – the input impedance is thousands of ohms and the output impedance is millions of ohms. Included in this transducer is protection for both input over-voltage and output short circuits.

High volume integrated circuit processing and simplicity of both electrical and mechanical design allows the LX1600A to be price competitive with individual basic sensor elements such as strain gauges, piezoelectric crystals and differential transformers, even though it performs the total pressure transducer function.

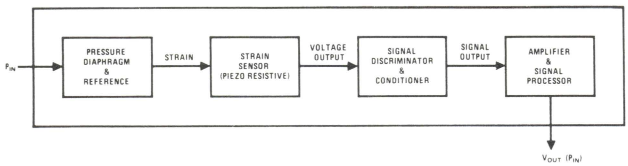
features

- Absolute Pressure Measurement – each unit contains a vacuum reference.
- Accuracy – maximum static error band of ±3% of full scale. Includes calibration error.
- Field interchangeability – all units meet one guaranteed characteristic curve.
- Easily installed with standard 3/16" flexible tubing and standard 5 pin electronic component sockets.
- Equivalent circuit is a simple potentiometer.
- Flexibility – single ended op amp configuration permits arithmetic functions, digital format, and multiplexing of 2 or more LX1600A's.
- Input overvoltage and output short circuit protection.
- Temperature measurement capability at point of pressure sensing.
- Extended pressure and temperature range capability.
- Availability through local National distributors.

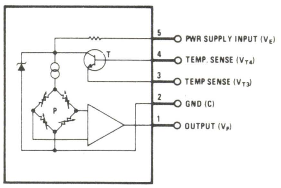
applications

- Fuel metering and ignition controls.
- Heating and ventilation, refrigeration and air conditioning controls.
- Altimetry, air data, and meteorology.
- Automotive safety and diagnostics.
- Pneumatic and pneumatic thermostat controls.
- Utility metering.
- Fluid systems proportional control.

block and connection diagrams



Total Useful Pressure Transducer



Order Number LX1600A
See Package 31

absolute maximum ratings

Excitation Voltage	30 V_{DC}
Output Current I_P	5 mA
Calibrated Pressure Range	0 to 1.0 Satm.
Pressure Over-Range	3.0 Satm.
Temperature Sensing Current I_{T34}	100 μA
Operating Temperature Range	–40 to +240°F
Extended Pressure Range	0 to 1.9 Satm.
Storage Temperature Range	–40 to +240°F
Lead Temperature (Soldering, 10 sec)	572°F

*electrical characteristics

PARAMETER	CONDITIONS (Note 1)	NOMINAL VALUE	MAXIMUM DEVIATION
Pressure			
Null Voltage (V_{PN})	T = 78°F, P = 0 atm., V_E = 12.5V	2.5 V_{DC}	±2% FS
Full Scale Voltage (V_{PFS})	T = 78°F, P = 1.0 Satm., V_E = 12.5V	7.5 V_{DC}	±2% FS
Null Temp. Coeff. (TC_{N1})	78°F $\leq$ T $\leq$ 180°F, P = 0 atm	0	±1.0 mV/°F
Full Scale Temp. Coeff. (TC_{FS1})	78°F $\leq$ T $\leq$ 180°F, P = 1.0 Satm.	0	±1.5 mV/°F
Null Temp. Coeff. (TC_{N2})	–40°F $\leq$ T $\leq$ 240°F, P = 0 atm.	0	±1.5 mV/°F
Full Scale Temp. Coeff. (TC_{FS2})	–40°F $\leq$ T $\leq$ 240°F, P = 1.0 Satm.	0	±2.0 mV/°F
Linearity	T = 78°F, P = 0.5 Satm.		±0.5% FS
Deadband	T = 78°F, P = 1.0 Satm.	0	±0.1% FS
Hysteretic Error	T = 78°F, P = 0.5 Satm.	0	±0.1% FS
Accuracy			
Static Error Band	T = 78°F,		±3.0% FS
Total Error Band	78°F $\leq$ T $\leq$ 180°F,		±3.5% FS
Total Error Band	–40°F $\leq$ T $\leq$ 240°F		±4.0% FS
Temperature		TYP	
Ref Voltage (V_{TREF})	T = 78°F, I_{T34} = 10 μA	7.0V	
Sensitivity ($\Delta V_T/\Delta T$)	–40°F $\leq$ T $\leq$ 240°F, I_{T34} = 10.0 μA	1.1 mV/°F	

*See Pg. 4 for Definition of Terms

Note 1: 78°F = 25°C, 180°F = 82°C, 240°F = 105°C, –40°F = –40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C.

typical applications

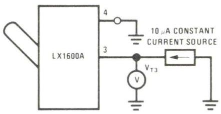
Absolute Pressure Transducer — Figure 1 — As would be expected a minimum of work is required — just combine one voltmeter, one LX1600A, and one 12.5 V_{DC} power supply as shown.

Differential Pressure Transducer — Figure 2 — The differential output between Pin 1 of the two LX1600A may be amplified by the addition of an LM107 and scaled to the output required by the proper selection of the resistor ratio R_4/R_3 and R_2/R_1.

It is possible to maintain the specified accuracies over the 10V min to 30V max useable range of excitation voltage (V_E). However, the regulation of the power supply voltage must be maintained within ±1% and for voltages other than 12.5V, a new calibration curve is necessary.

The LX1600A with its small size and standard electronic and pnuematic connections has been designed for ease of installation in other packages when the application involves harsh or corrosive environments.

The temperature sensor of the LX1600A is activated by grounding Pin 4 and connecting Pin 3 to a 10 μA constant current source as shown. Then V_{TE} measured with a 10 megohm voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated.



For Temperature Sensing

typical applications (con't)

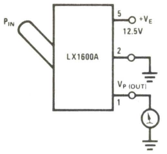


Figure 1. Absolute Pressure Transducer

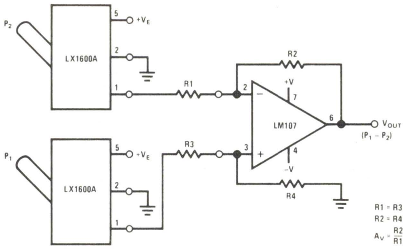


Figure 2. Differential Pressure Transducer

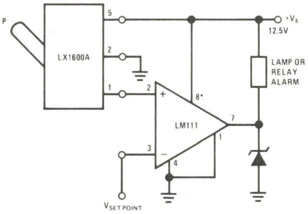


Figure 3. Single Ended LIMIT Detector

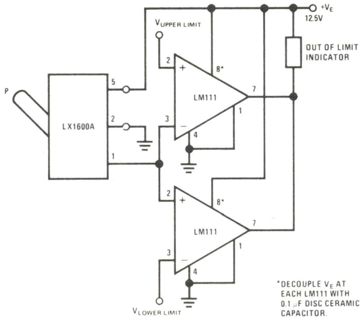
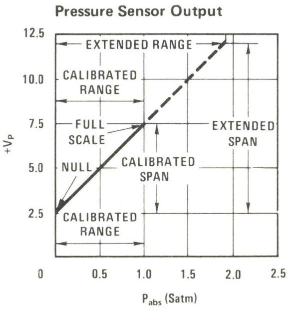
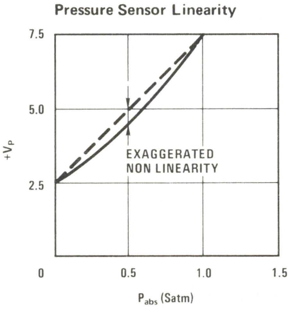
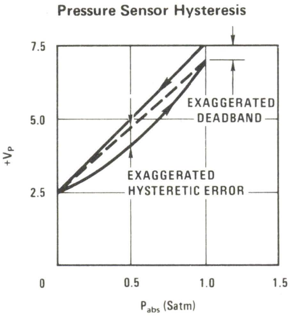


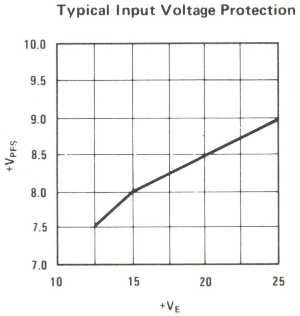
Figure 4. Double Ended LIMIT Detector

typical performance characteristics









Functional Blocks

LX1601A/LX1602A/LX1603A, LX1701A/LX1702A/LX1703A absolute LX1601G/LX1602G/LX1603G/LX1604G, LX1701G/LX1702G/LX1703G/LX1704G gage LX1601D/LX1602D/LX1603D/LX1604D differential pressure transducers 0–30psi

general description

These rugged devices are highly accurate, completely field interchangeable, temperature compensated linear pressure transducers.

All of the basic transduction elements are incorporated in one hybrid package. A totally useful pressure transducer is shown in the block diagram below—the diaphragm and pressure reference, piezoresistive sensor, signal discriminator, and signal amplifier and processor. The first three functional elements are contained in a single silicon die and the fourth is provided by standard National linear IC operational amplifiers.

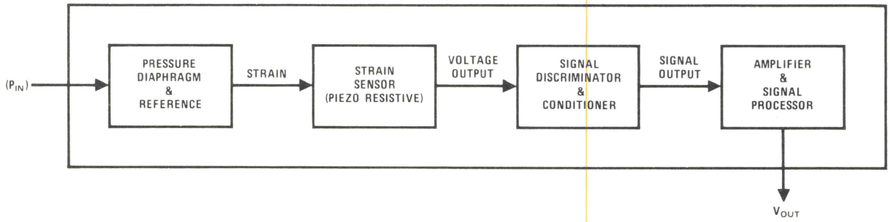
applications

- Medical electronics
- Altimetry, air data, and meteorology
- Computer pneumatics
- Fluid system proportional control
- Hydraulics
- Pneumatic controls
- Heating, ventilation, refrigeration and air conditioning controls
- Automotive emission control, safety, and diagnostic systems

features

- Field interchangeability—by using computerized laser trim all units meet one guaranteed characteristic curve.
- Accuracy—maximum calibration error band of ±1.5% of span
- Temperature compensated—transducer temperature effects offset by computerized laser trimming
- Flexibility—arithmetic functions, digital format and multiplexing are easily attainable because of the single ended op amp configuration
- Input overvoltage and output short circuit protection
- Low mass, no moving parts, good frequency response
- Temperature measurement capability at point of pressure sensing
- Available from local National distributor

block diagram



Total Useful Pressure Transducer

PRODUCT SELECTION GUIDE

absolute maximum ratings

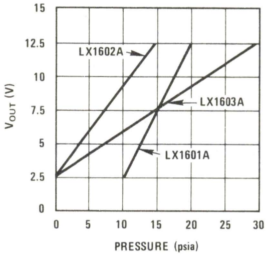
Excitation Voltage	30 V_{DC}
Output Current	5 mA
Temperature Sensing Current	100μA
Operating and Storage Temperature Range	−40°F to +240°F
Bias Current at 15V Excitation	15 mA
Lead Temperature (Soldering, 10 sec)	572°F

(See Note 5 and 6)

nominal characteristics (+70°F, 15V excitation)

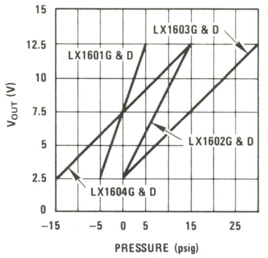
ABSOLUTE TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psia)		
±1.5% Span (±150 mV)		LX1601A LX1701A	LX1602A LX1702A	LX1603A LX1703A
2.5V	Low Pressure End Point	10	0	0
7.5V	Mid-Range	15	7.5	15
12.5V	High Pressure End Point	20	15	30
Maximum Allowable Over-Pressure		40	40	50



GAGE AND DIFFERENTIAL TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psig)			
±1.5% Span (±150 mV)		LX1601G LX1701G LX1601D	LX1602G LX1702G LX1602D	LX1603G LX1703G LX1603D	LX1604G LX1704G LX1604D
2.5V	Low Pressure End Point	−5	0	0	−15
7.5V	Mid-Range	0	7.5	15	0
12.5V	High Pressure End Point	+5	15	30	+15
Maximum Allowable Over-Pressure		30	40	50	40



Note 1: All nominal characteristics calibrated with 15V excitation and +70° Farenheit.

Note 2: The 17 series package is available for absolute and gage units only.

Note 3: Refer to the physical specifications, page 4, for the proper pressure connections to all differential units.

Note 4: To maintain the specified tolerances, the power supply must be regulated to within ±1%. These transducers can be calibrated for any excitation voltage from 10V to 30V.

Note 5: The unit may not withstand corrosive working fluid. In addition to standard die passivation a chemical coating is added to permit use with many common non-conductive working gas and liquids. For specific requirements, consult the factory.

Note 6: The transducers are not electrically isolated from the working fluid.

ELECTRICAL SPECIFICATIONS

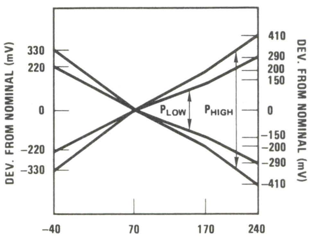
combined linearity and hysteresis

±50 mV (±0.5% Span)

output voltage temperature tolerance

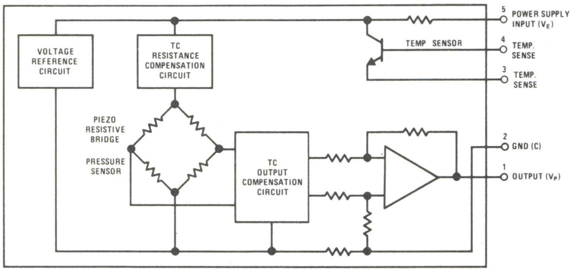
NOMINAL OUTPUT VOLTAGE		MAX TEMP COEFFICIENT ±mV/°F	MAX ERROR OVER TEMP RANGE ±mV	MAX ERROR OVER TEMP RANGE % SPAN
Calibrated Temp Range +70°F ≤ T ≤ +170°F				
2.5V	Low Pressure End Point	1.5	150	1.5%
12.5V	High Pressure End Point	2	200	2%
Full Temp Range −40°F ≤ T < 240°F				
2.5V	Low Pressure End Point	2	290	3%
12.5V	High Pressure End Point	3	410	4%

Temperature Error Band

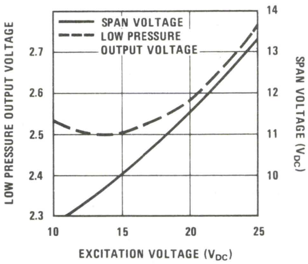


V_{OUT} = 2.5V AT P_{LOW}, V_{OUT} = 12.5V AT P_{HIGH}

connection diagram



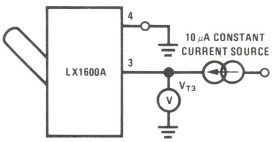
Typical Excitation Voltage Tracking



temperature sensor

The temperature sensor of the transducer is activated by grounding pin 4 and connecting pin 3 to a 10μA constant current source as shown. Then V_{T3} measured with a 10 MΩ voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated. When connected in this fashion the typical reference voltage is 7V with a sensitivity of 1.1 mV/°F.

Temperature Sensing Connection



Note: 70°F = 21°C, 170°F = 78°C, 240°F = 116°C, −40°F = −40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C, 1 psi = 51.71 TORR (mmHg) = 2.036 in Hg = 27.67 in H_2O = 2.307 ft H_2O = 68.95 mbar.

Functional Blocks

LX1610A/LX1620A/LX1630A, LX1710A/LX1720A/LX1730A absolute LX1610G/LX1620G/LX1630G, LX1710G/LX1720G/LX1730G gage LX1610D/LX1620D differential pressure transducers 0–300psi

general description

These rugged devices are highly accurate, completely field interchangeable, temperature compensated linear pressure transducers.

All of the basic transduction elements are incorporated in one hybrid package. A totally useful pressure transducer is shown in the block diagram below—the diaphragm and pressure reference, piezoresistive sensor, signal discriminator, and signal amplifier and processor. The first three functional elements are contained in a single silicon die and the fourth is provided by standard National linear IC operational amplifiers.

applications

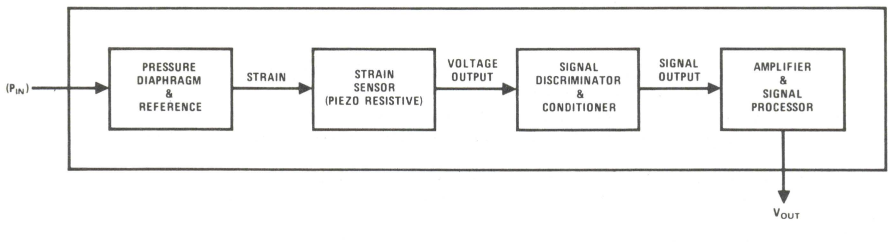
- Medical electronics
- Altimetry, air data, and meteorology
- Computer pneumatics
- Fluid system proportional control
- Hydraulics
- Pneumatic controls
- Heating, ventilation, refrigeration and air conditioning controls
- Automotive emission control, safety, and diagnostic systems

features

- Field interchangeability—by using computerized laser trim all units meet one guaranteed characteristic curve.
- Accuracy—maximum calibration error band of ±1.5% of span
- Temperature compensated—transducer temperature effects offset by computerized laser trimming
- Flexibility—arithmetic functions, digital format and multiplexing are easily attainable because of the single ended op amp configuration
- Input overvoltage and output short circuit protection
- Low mass, no moving parts, good frequency response
- Temperature measurement capability at point of pressure sensing
- Available from local National distributor

4

block diagram



Total Useful Pressure Transducer

PRODUCT SELECTION GUIDE

absolute maximum ratings

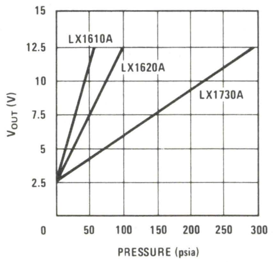
Excitation Voltage	30 V_{DC}
Output Current	5 mA
Temperature Sensing Current	100μA
Operating and Storage Temperature Range	−40°F to +240°F
Bias Current at 15V Excitation	15 mA
Lead Temperature (Soldering, 10 sec)	572°F

(See Note 5 and 6)

nominal characteristics (+70°F, 15V excitation)

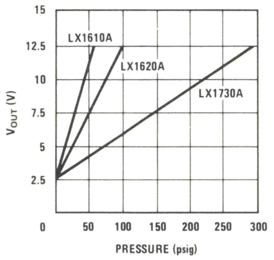
ABSOLUTE TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psia)		
±1.5% Span (±150 mV)		LX1610A LX1710A	LX1620A LX1720A	LX1730A
2.5V	Low Pressure End Point	0	0	0
7.5V	Mid-Range	30	50	150
12.5V	High Pressure End Point	60	100	300
Maximum Allowable Over-Pressure		100	150	500



GAGE AND DIFFERENTIAL TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psig)		
±1.5% Span (±150 mV)		LX1610G LX1710G LX1610D	LX1620G LX1720G LX1620D	LX1730G
2.5V	Low Pressure End Point	0	0	0
7.5V	Mid-Range	30	50	150
12.5V	High Pressure End Point	60	100	300
Maximum Allowable Over-Pressure		100	150	500



Note 1: All nominal characteristics calibrated with 15V excitation and +70° Farenheit.

Note 2: The 17 series package is available for absolute and gage units only.

Note 3: Refer to the physical specifications, page 4, for the proper pressure connections to all differential units.

Note 4: To maintain the specified tolerances, the power supply must be regulated to within ±1%. These transducers can be calibrated for any excitation voltage from 10V to 30V.

Note 5: The unit may not withstand corrosive working fluid. In addition to standard die passivation a chemical coating is added to permit use with many common non-conductive working gas and liquids. For specific requirements, consult the factory.

Note 6: The transducers are not electrically isolated from the working fluid.

ELECTRICAL SPECIFICATIONS

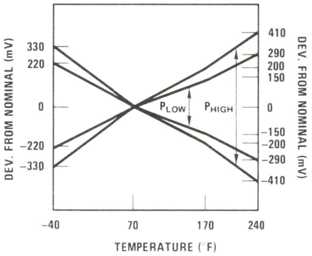
combined linearity and hysteresis

±75 mV (±0.75% Span)

output voltage temperature tolerance

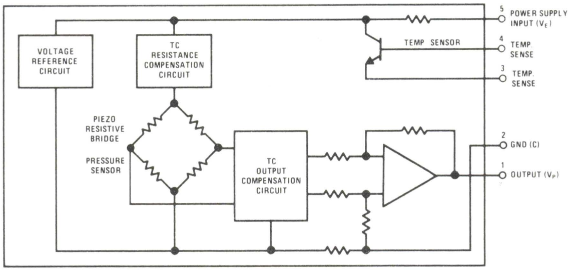
NOMINAL OUTPUT VOLTAGE		MAX TEMP COEFFICIENT ±mV/°F	MAX ERROR OVER TEMP RANGE ±mV	MAX ERROR OVER TEMP RANGE % SPAN
Calibrated Temp Range +70°F ≤ T ≤ +170°F				
2.5V	Low Pressure End Point	1.5	150	1.5%
12.5V	High Pressure End Point	2	200	2%
Full Temp Range −40°F ≤ T < 240°F				
2.5V	Low Pressure End Point	2	290	3%
12.5V	High Pressure End Point	3	410	4%

Temperature Error Band

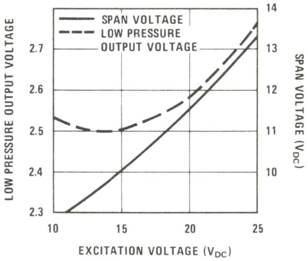


V_{OUT} = 2.5V AT P_{LOW}, V_{OUT} = 12.5V AT P_{HIGH}

connection diagram



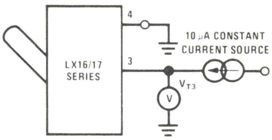
Typical Excitation Voltage Tracking



temperature sensor

The temperature sensor of the transducer is activated by grounding pin 4 and connecting pin 3 to a 10μA constant current source as shown. Then V_{T3} measured with a 10 MΩ voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated. When connected in this fashion the typical reference voltage is 7V with a sensitivity of 1.1 mV/°F.

Temperature Sensing Connection



Note: 70°F = 21°C, 170°F = 78°C, 240°F = 116°C, −40°F = −40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C, 1 psi = 51.71 TORR (mmHg) = 2.036 in Hg = 27.67 in H_2O = 2.307 ft H_2O = 68.95 mbar.

Functional Blocks

PSM6501 ±15V, 100mA power supply module

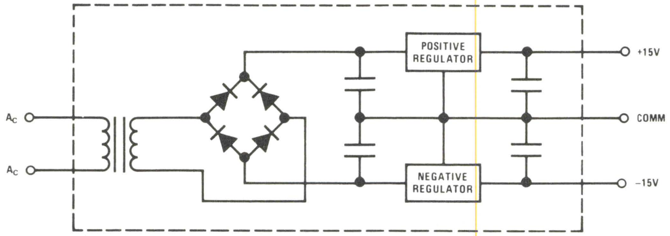
general description

The PSM6501 is a ±15V modular power supply capable of continuously delivering 100 mA DC minimum. The required input voltage is 105V to 125V AC at 50 Hz to 440 Hz. This supply incorporates short circuit protection, thermal shutdown protection to prevent thermal runaway and safe operating area compensation in the output devices to limit internal power dissipation. Integrated circuits are used extensively to improve reliability.

features

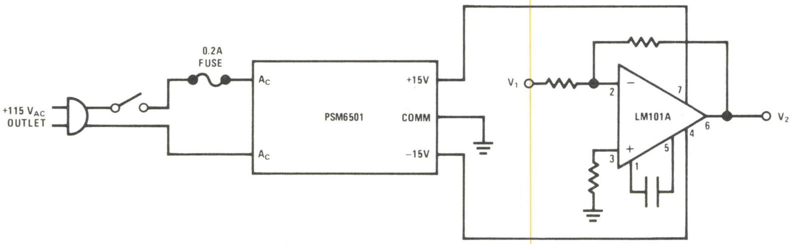
- Complete compact plug-in module
- Excellent line and load regulation
- AC input, DC output
- Output short circuit protection
- Thermal shutdown — avoids runaway
- Safe area compensation

equivalent circuit



typical application

Operational Amplifier Power Supply



Order Number PSM6501
(For Matching Socket Order Part Number SKT0001)
See Package 34

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	50 Hz - 440 Hz	105		125	V_{AC}
V_{OUT} Positive		15		15.30	V_{DC}
V_{OUT} Negative		−15		−15.30	V_{DC}
I_{OUT}		±100			mA
V_{OUT} Tracking				0.1	%
V_{OUT} Tempco				0.015	%/°C
Line Regulation	±10 V_{AC}		0.02	0.05	%
Load Regulation	0 mA - 100 mA		0.03	0.1	%
Isolation			50		MΩ
R_{OUT}	10 kHz		0.2		Ω
Ripple & Noise				0.5	mVrms
Warm-up Drift				45	mV

Note 1: All parameters apply for T_A = 25°C, V_{IN} = 115 Vrms @ 60 Hz, unless otherwise noted.

The PSM6501 replaces the following part types:	
902	ZM15100
543	MD15D
2212	P1106
LCD2.15.100	SE902
SP5902	

Functional Blocks

SHM6401 sample and hold module

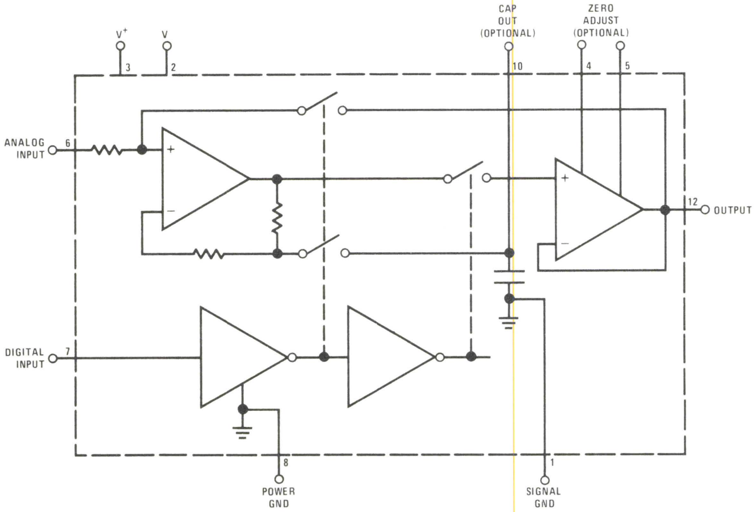
general description

The SHM6401 is a compact sample and hold module capable of acquiring and holding an analog signal upon command of a digital pulse. A high impedance input buffer, complete digital logic, 3 analog switches, hold capacitor and a FET input hold amplifier are all included within the package. Higher accuracy may be obtained by adding an external trim pot and capacitor.

features

- Self contained plug-in module
- High accuracy 0.01%
- TTL, DTL compatible logic
- Analog signal range ±10V
- Low droop rate 10 mV/sec max
- High input impedance
- Standard power supplies ±15V
- Low acquisition time

equivalent circuit



NOTE: HOLD MODE (LOGIC "0") SHOWN. ALL OTHER PINS NO CONNECT

Order Number SHM6401
See Package 35

absolute maximum ratings

Analog Input Voltage Range	±15V
Digital Input Voltage	5.5V
Analog Supply Voltage (V^+ to V^-)	40V
Short Circuit	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−55°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

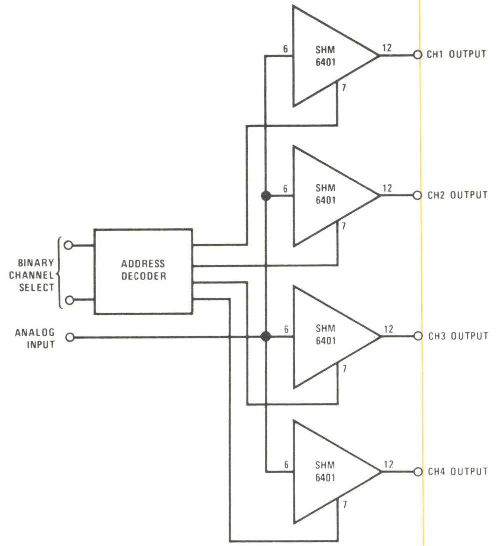
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Accuracy	R_L = 2kΩ			±0.01	%
Voltage Gain			1		
Voltage Gain Temperature Coefficient				±1	PPM/°C
Frequency Response	Tracking, −3 dB, Small Signal		50		kHz
Frequency Response	Tracking, Full Power $20V_{P\text{-}P}$ Sine Wave		10		kHz
Slew Rate			0.5		V/μs
Sample Mode Settling Time	To ±1 mV, 10V Step Input		75		μs
Input Overload Recovery	To ±1 mV, 50% Overvoltage		150		μs
Input Voltage Range		±10			V
Input Resistance	Sample Mode	100			MΩ
Input Bias Current	Sample Mode		400		nA
Input Offset Voltage	Sample Mode		20		mV
Input Offset Voltage Temperature Coefficient	0°C to +70°C		10		μV/°C
Power Supply Rejection Ratio				0.015	$mV/\%\Delta V_S$
Output Swing	R_L = 2kΩ	±10			V
Output Current	R_L = 2kΩ	±10			mA
Load Capacitance	No Oscillation		1000		pF
Wide Band Output Noise	Hold Mode, Grounded Input		1		mVrms
Droop Rate	Hold Mode, +25°C			10	mV/s
Droop Rate	0°C to +70°C		Doubles Every 10°C		
Signal Feed Through	Hold Mode, $20V_{P\text{-}P}$, Sine Wave, 10 kHz			2	$mV_{P\text{-}P}$
Aperature Time	Sample to Hold Transition			50	ns
Offset Step	Sample to Hold Transition			1	mV
Transition Settling Time	To ±1 mV of Final Value, Sample to Hold Transition			10	μs
Transition Settling Time	To ±1 mV, Hold to Sample Transition			100	μs
Acquisition Time	20V Step to ±1 mV of Final Value, Hold to Sample Transition			130	μs
Logic High	I = 5μA Max	2		5.5	V
Logic Low	I = 0.5 mA Max	−0.5		0.8	V
Supply Current				8	mA

Note 1: All specifications apply for V_S = ±15V, T_A = 25°C unless otherwise specified.

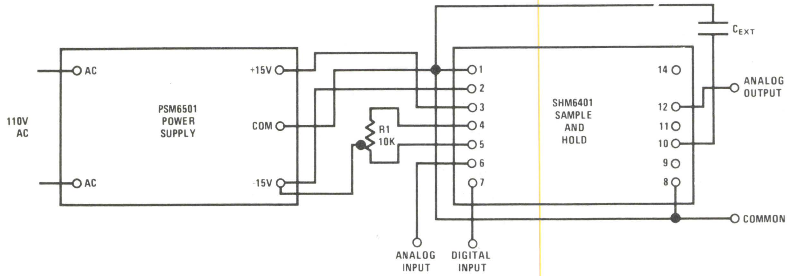
4

typical application

Analog Data Distribution System



high accuracy connection



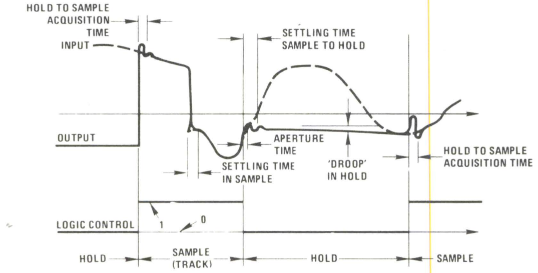
NOTE 1: MAX DROOP RATE = d_v/d_t = $[0.1 \times 10^{-9}/(10 \times 10^{-9} + C_{EXT})]$ V/SEC.

NOTE 2: TO ZERO ADJUST, SET DIGITAL INPUT TO SAMPLE MODE, APPLY 0V TO THE ANALOG INPUT, AND TRIM R1 UNTIL ANALOG OUTPUT READS 0V.

NOTE 3: SIGNAL GROUND AND ANALOG GROUND SHOULD BE TIED TOGETHER AT ONE POINT NEAR THE SUPPLY.

NOTE 4: C_{EXT} SHOULD BE LOW LEAKAGE TEFLON, POLYCARBONATE OR POLYSTYRENE.

explanation of terminology



Consumer Circuits

LM170/LM270/LM370 agc/squelch amplifier

general description

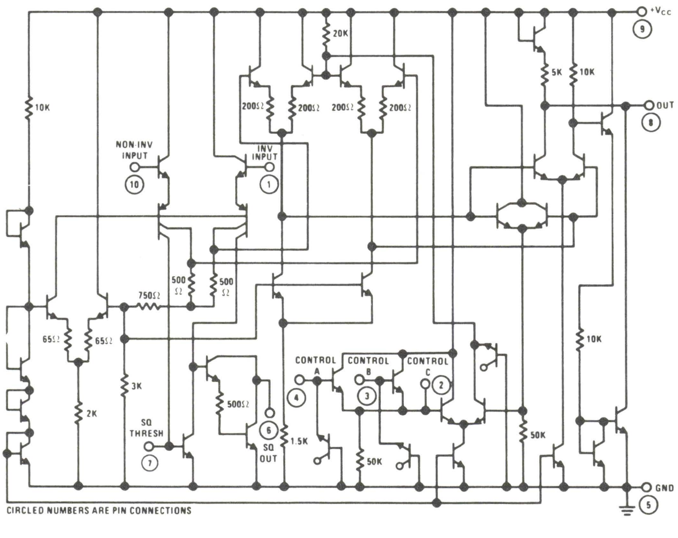
The LM170 is a direct coupled monolithic amplifier whose voltage gain is controlled by an external DC voltage. The device features:

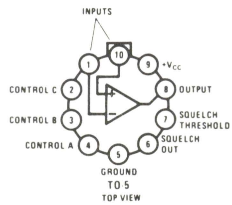
- Large Gain Control Range
- Self-contained AGC/Squelch system, with fast-attack, slow-release.
- Low Distortion
- Minimum DC output shift as gain is varied
- Differential inputs, with large common-mode input range
- Outputs of several amplifiers may be directly summed in multichannel systems.
- Dissipates only 18 mW from +4.5V supply, usable with supply up to +24V.
- Sensitive squelch threshold set by single external resistor.

In addition to communication system squelch and AGC applications, the LM170 is useful as constant-amplitude audio oscillator, linear low frequency modulator, single-sideband automatic load control, and as a variable DC gain element in analog computation.

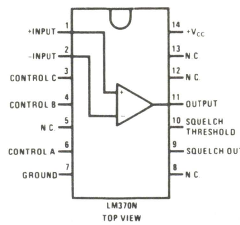
The LM170 is specified for operation over the −55°C to +125°C military temperature range. The LM270 is specified for operation over the −25°C to +75°C temperature range. The LM370 is specified for operation over the 0°C to +70°C temperature range.

schematic** and connection diagrams





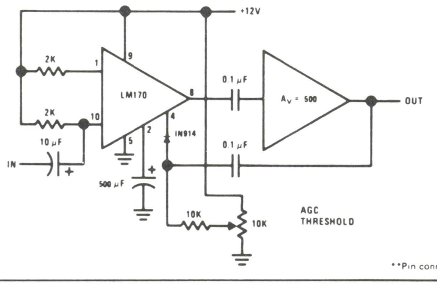
Order Number LM170H or LM270H or LM370H See Package 14



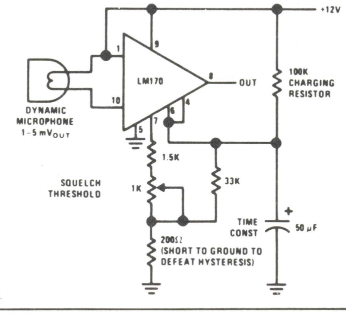
Order Number LM370N See Package 22

typical applications**

AGC Using Built-in Detection, Driven By Additional System Gain



Squelched Preamplifier with Hysteresis



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	24V
Storage Temperature	−65°C to +150°C
Operating Temperature LM170	−55°C to +125°C
LM270	−25°C to +75°C
LM370	0°C to +70°C
Differential Input Voltage	±19.5V
Common-mode Input Voltage	$(V_{CC} + 0.4)$V
Output Short Circuit Duration	Indefinite
Voltage applied to Pin 3 or 4	+6.0V
Voltage applied to Pin 2	+12.0V
Surge power into Pin 6 (1 second max.)	1000 mW
Continuous power into Pin 6	100 mW

electrical characteristics (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
DC Output Voltage	V_O(DC)	V_{IN} (dd) = 0, V (gain control) = 0	+5.0	+6.0	+7.0	V
DC Output Voltage	V_O(DC)	V_{IN} (dd) = 0 V (gain control) = +3.0	+5.0	+6.0	+7.0	V
DC Output Shift	ΔV_O(DC)	V_{IN} (dd) = 0 V (gain control) changed from 0 to +3.0V				
		LM170	−200	0	+200	mV
		LM270	−500	0	+500	mV
		LM370	−1000	0	1000	
Power Supply Drain	I_{PS}	V_{CC} = +24V		13.5		mA
		V_{CC} = +4.5V		4.0		
		V_{CC} = +12V LM170, 270		8.0	10.0	mA
		LM370		8.0	12.0	mA
Input Bias Current	I_{IB}	LM170, 270		5.0	10.0	µA
		LM370		5.0	12.0	
AC CHARACTERISTICS						
Voltage Gain	A_V	V (gain control) = 0				
		LM170, 270	37.5	40.0		
		LM370	35.0	40.0		dB
		f = 1 KHz				
Gain Reduction Range	ΔA_V	V (gain control) changed from 0 to +3.0V. Gain reduction occurs for control voltages between +2.1 and +2.5 volts, pin 3 or pin 4. f = 1 KHz		−80.0		dB

Note 1: T_A = 25°C, V_{CC} = +12V, $V_{IN(cm)}$ = +6V

operating notes

Voltage gain is continuously variable from a maximum value, dependent upon supply voltage, to a minimum value, by application of a DC control voltage at Pin 3 or 4. DC output voltage is substantially independent of gain changes, provided that differential DC input voltage is minimized, so that direct-coupled or fast gain-control operation is possible with minimum disturbance of succeeding amplifiers.

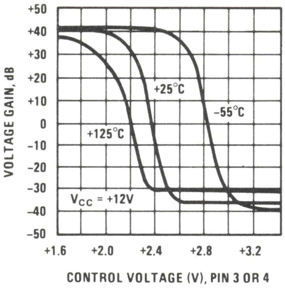
Input characteristics are similar to those of an operational amplifier, with common-mode input range extending from +4.5 volts up to and including the positive supply voltage. Lowest distortion occurs at input levels of 20 mV p-p or less. Outputs of several amplifiers, which will have quiescent DC levels approximately half of the positive supply, may be directly connected together in multi-channel summing systems, without damage.

Emitter-follower control inputs, Pins 3 and 4, may be used as positive peak detectors by connecting a smoothing capacitor at Pin 2, in AGC applications.

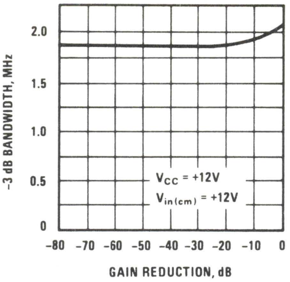
A sensitive squelch detector, independent of the amplifier's gain, provides fast-attack, slow release control at Pin 6, with threshold set by an external resistance from Pin 7 to ground. Injecting a portion of the control voltage at Pin 6 into this threshold results in a hysteresis, reducing response to erratic inputs. Since threshold is dependent on DC levels, differential DC input voltage should be held constant for squelch operation.

variable gain characteristics

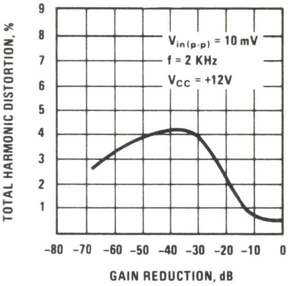
Voltage Gain vs Control Voltage



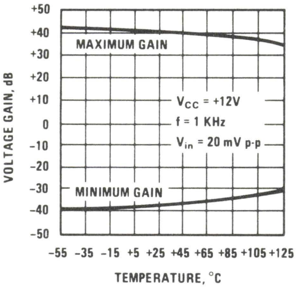
Bandwidth vs Gain Reduction



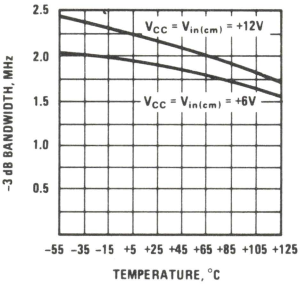
Total Harmonic Distortion vs Gain Reduction



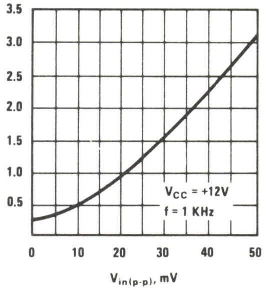
Maximum and Minimum Voltage Gain vs Temperature



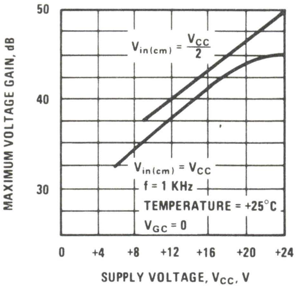
Bandwidth vs Temperature



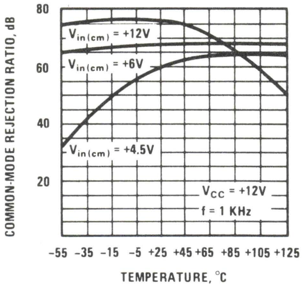
Total Harmonic Distortion vs Input Amplitude



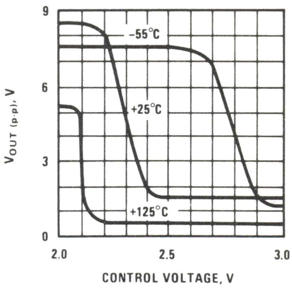
Maximum Voltage Gain vs Supply Voltage



Common-Mode Rejection Ratio vs Temperature

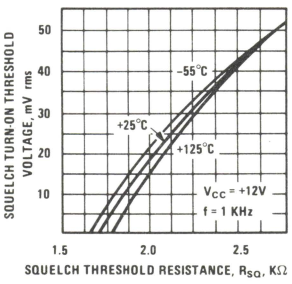


Output Dynamic Range vs Control Voltage

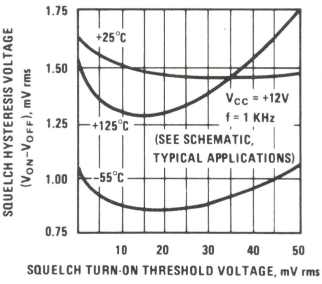


squelch characteristics

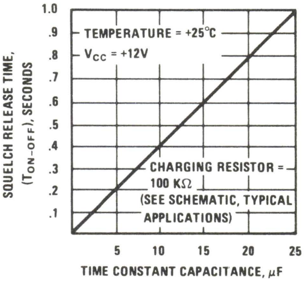
Squelch Threshold Voltage vs Threshold Resistance



Squelch Hysteresis Voltage vs Squelch Threshold Voltage

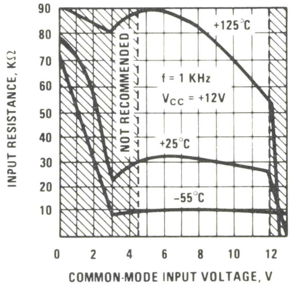


Squelch Release Time vs Time Constant Capacitance

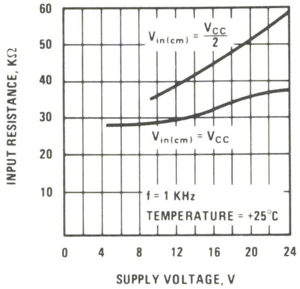


input and output characteristics

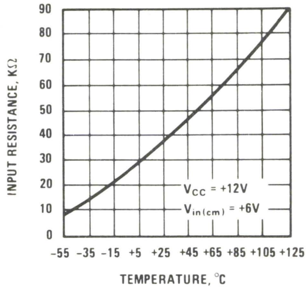
Input Resistance vs Common-Mode Input Voltage



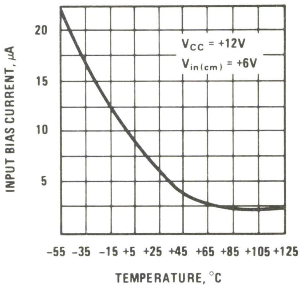
Input Resistance vs Supply Voltage



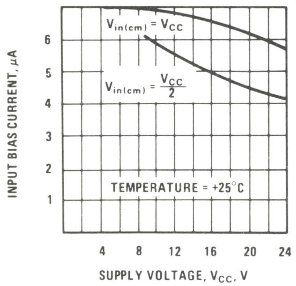
Input Resistance vs Temperature



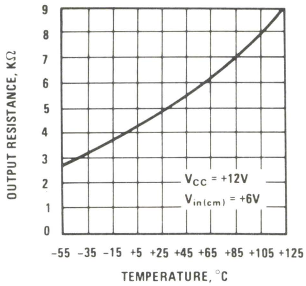
Input Bias Current vs Temperature



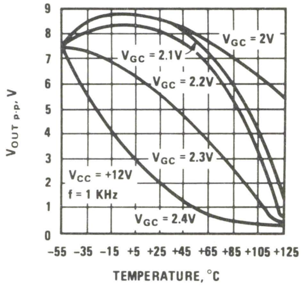
Input Bias Current vs Supply Voltage



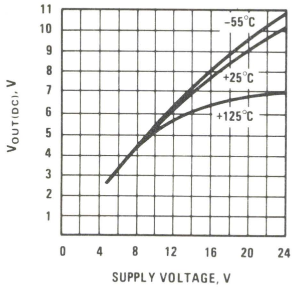
Output Resistance vs Temperature



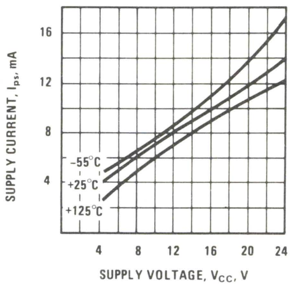
Output Dynamic Range vs Temperature



Quiescent DC Output Voltage vs Supply Voltage



Power Supply Current vs Supply Voltage



Consumer Circuits

LM171/LM271/LM371 integrated rf/if amplifier

general description

The LM171/LM271/LM371 is a monolithic RF-IF amplifier capable of emitter coupled or cascode operation from DC to 250 MHz. Wide versatility is offered by having all inputs and outputs brought out so many circuit configurations are possible.

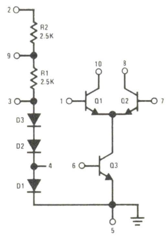
features

- Low internal feedback, allowing high stability-limited gain
- Versatility through user-connected configurations
- As emitter coupled amplifier, symmetrical, non-saturated limiting
- As cascode, wide AGC range with constant input admittance
- As differential DC amplifier, low input offset voltage and wide dynamic range
- As video amplifier, externally selected gain, and high gain-bandwidth product
- 100 MHz tuned power gain

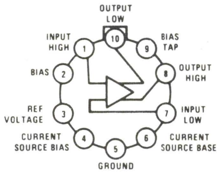
(Emitter Coupled)	24.6 dB
(Cascode)	27.5 dB

In addition to amplifier service, the circuit is useful in mixer, oscillator, detector, modulator, and numerous other applications. The LM271 is a plug-in replacement for the 911C type.

schematic and connection diagrams



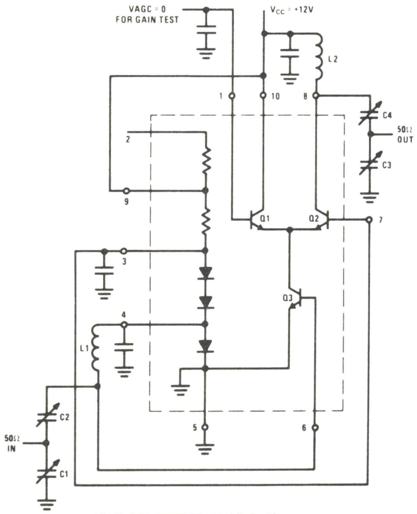
Metal Can Package



Order Number LM171H
or LM271H or LM371H
See Package 14

typical applications

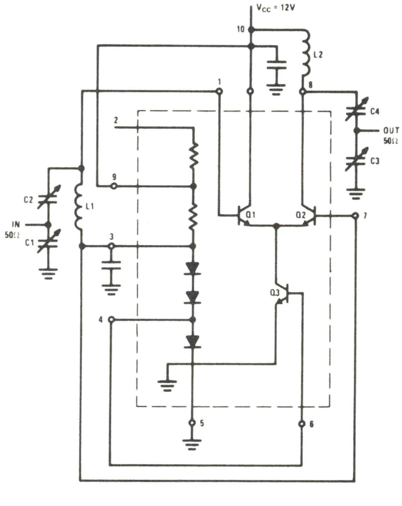
100 MHz Cascode Test Circuit



C1 = C3 = 9-36 pF TRIMMER   L1 = L2 = 7t. #16 a.w.g.
C2 = C4 = 2-8 pF TRIMMER   SPACED 1 TURN, 1/4" INSIDE DIAM.

FIGURE 1

100 MHz Emitter Coupled Test Circuit



C1 = C3 = 9-36 pF TRIMMER   L1 = L2 7t. #16 a.w.g.
C2 = C4 = 2-8 pF TRIMMER   SPACED 1 TURN, 1/4" INSIDE DIAM.

FIGURE 2

Note: All unmarked bypass capacitors 1000 pF.

absolute maximum ratings

Supply Surge Voltage		30V
Supply Operating Voltage		24V
Storage Temperature		$-65^\circ C$ to $+150^\circ C$
Operating Temperature	LM171	$-55^\circ C$ to $+125^\circ C$
	LM271	$0^\circ C$ to $+100^\circ C$
Power Dissipation		230 mW
Voltage between 1 and 7		±5V
Voltage between 4 and 6		±5V

electrical characteristics These specifications apply for $V^+ = +12V$ and $T_A = 25^\circ C$

PARAMETER	CONDITIONS	LM171			LM271			LM371			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
DC CHARACTERISTICS											
Input Offset Voltage (V_{OS})	$I_8 = I_{10} = 500\ \mu A$			3			3			10	mV
Input Bias Current (I_{BIAS})		1.30		2.65	1.3		2.65	1.3		2.65	mA
Ratio of R1/R2		0.895		1.12	0.895		1.12	0.895		0.895	
Voltage at Pin 3 (V_3)	$V_2 = +12V$	2.0			2.0			2.0			V
Current Through Current Source Q3 (I_C)	$I_C = I_8 + I_{10}$	2.45		5.70	2.45		5.70	2.45		5.70	mA
Current Gain (β)		40			40			40			
Power Supply Current Drain (I_{PS})	$I_{PS} = I_{BIAS} + I_8 + I_{10}$			9.0			9.0			10.5	mA

EMITTER COUPLED CHARACTERISTICS (Input Signal < 10 mVrms) LM171, LM271, LM371

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Conductance (G_{11})	455 kHz		0.30	0.40	mmhos
Output Conductance (G_{22})	455 kHz		0.01	0.04	mmhos
Magnitude of Forward Transadmittance ($\lvert Y_{21}\rvert$)	455 kHz	17.0	27.0		mmhos
Magnitude of Reverse Transadmittance ($\lvert Y_{12}\rvert$)	200 MHz		0.1		mmhos
Tuned Power Gain (A_P)	10.7 MHz BW = 470 kHz		24.6		dB
Tuned Power Gain (A_P)	100 MHz BW = 5 MHz		22.7		dB

CASCODE CHARACTERISTICS (Input Signal < 10 mVrms) LM171, LM271, LM371

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Conductance (G_{11})	455 kHz		1.1	2.5	mmhos
Output Conductance (G_{22})	455 kHz Connect Pin 1 to 7		0.01	0.04	mmhos
Magnitude of Forward Transadmittance ($\lvert Y_{21}\rvert$)	455 kHz Pin 1 GND	25.0	50.0		mmhos
Magnitude of Reverse Transadmittance ($\lvert Y_{12}\rvert$)	200 MHz 100 MHz		0.001		mmhos
Tuned Power Gain (A_P)	Pin 1 GND BW = 5 MHz		27.5		dB
Tuned Power Gain (A_P)	Pin 1 GND BW = 6 MHz		25.0		dB

THE FOLLOWING PARAMETERS APPLY FOR THE LM171 FOR $-55^\circ C < T_A < +125^\circ C$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Magnitude of Forward Transadmittance (Emitter Coupled) ($\lvert Y_{21}\rvert$)	455 kHz $e_{in} < 10$ mV rms	17.0			mmhos
Magnitude of Forward Transadmittance (Cascode) ($\lvert Y_{21}\rvert$)	455 kHz $e_{in} < 10$ mV rms Pin 1 GND	21.0			mmhos

biasing considerations

The active portion of the 171 is biased by monolithic matching of constant-current transistor Q3 and diode D1. R1 and R2 may be connected in one of four ways to force a current from V_{CC} through three diodes. Alternatively, an external resistor may be used. If pin 4 is connected to pin 6, directly, or through an inductor or resistor having less than 100 ohms DC resistance, the current drawn by Q3 will approximately equal that forced through D1.

Pin 3 may be used as a DC reference voltage, to bias pins 1 and 7, and is approximately the minimum voltage required to guarantee proper current source collector characteristics.

Typical Biasing for Emitter Coupled Amplifier

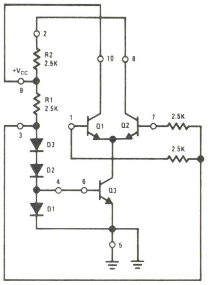
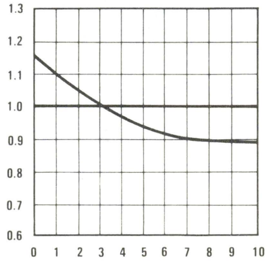
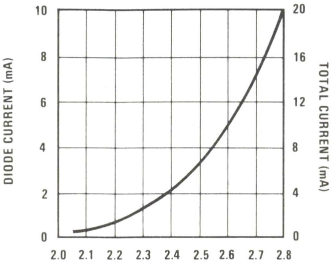


FIGURE 3

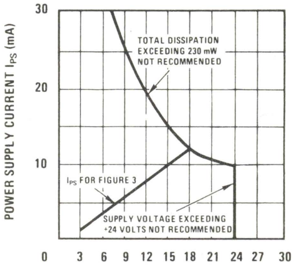
Current Source – Diode Current Ratio vs Current Forced Through Diode Chain



DC Reference Voltage (3 to 5) vs Diode Chain Current and Supply Current

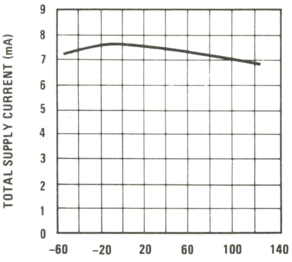


Total Supply Current vs Supply Voltage

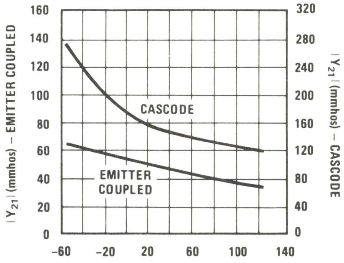


typical temperature characteristics

Total Supply Current vs Temperature, V_{CC} = +12V



Magnitude of Forward Transadmittance vs Temperature, V_{CC} = +12V, 455 kHz



cascode configuration

The common-emitter, common-base, or cascode, configuration is useful as a tuned RF or IF amplifier to 250 MHz. Two common-base stages are formed by the differential pair, Q1 and Q2, which may be used as a gain control system by applying a differential gain control voltage between pins 1 and 7. With Q1 cut off, maximum gain is obtained, being reduced as Q1 is progressively turned on and Q2 turned off. The input common-emitter transistor presents a nearly constant input admittance as AGC is applied.

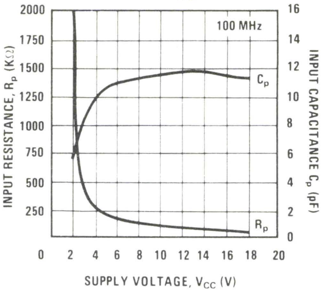
DC input bias is obtained through the input inductor from the bias chain, pin 4.

Pin 3 may be used as the DC reference for the AGC input, to assure adequate bias voltage for the collector of Q3. Where large AGC voltages are used, an external resistive divider, from pin 3 to 1 to the

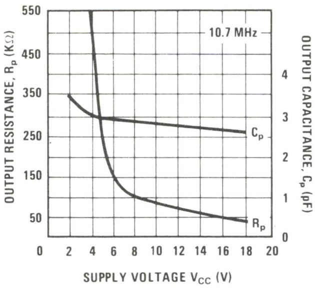
AGC voltage may be used to optimize the DC AGC requirements. VAGC is defined as the voltage between pin 1 and 7.

At some frequencies, bypassing may be required at pins 1, 3, 4 or the V_{CC} connection.

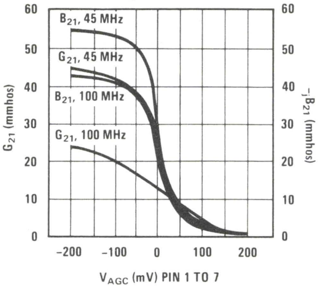
Input Resistance and Capacitance vs V_{CC}



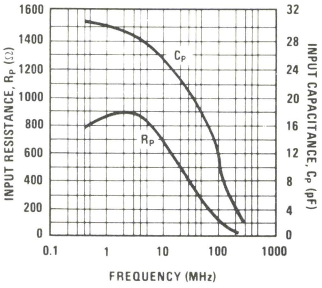
Output Resistance and Capacitance vs V_{CC}



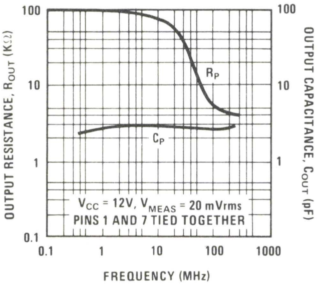
Forward Transadmittance vs AGC Voltage



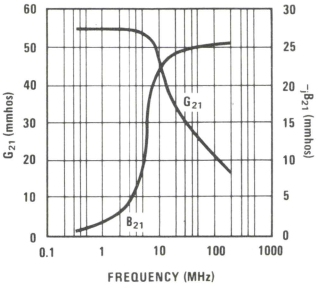
Input Resistance and Capacitance vs Frequency @ 12 Volts V_{CC}



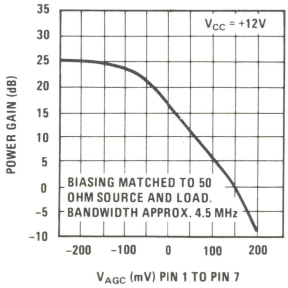
Output Resistance and Capacitance vs Frequency



Forward Transadmittance vs Frequency, V_{AGC} = 0V



Tuned Power Gain vs AGC Voltage



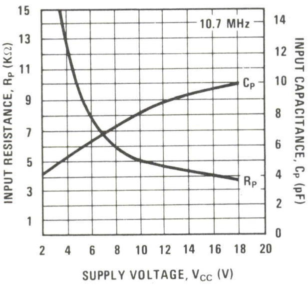
emitter coupled configuration

The common-collector, common-base, or emitter-coupled configuration is useful as a symmetrically non-saturated limiting RF or IF amplifier to 150 MHz. Basically a differential amplifier, this configuration is especially suited to FM IF strips using conventional interstage tuning. While available gain is lower and noise figure higher than the cascode, emitter coupled operation may be considered wherever fast recovery from large-signal overdrive or excellent AM rejection is required.

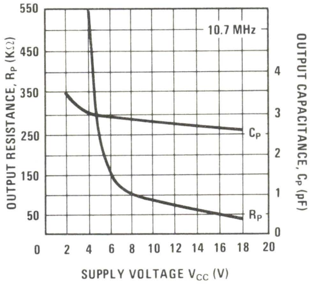
Q3 is used as a current source, obtaining its bias from the diode chain. Current available from Q3 is shunted through Q1 or Q2, depending on input signal, and is equally divided when no signal is present, assuring inherently symmetrical operation. DC bias for pin 7 is obtained from the divider chain, and through the input inductor, the same bias is applied to pin 1.

For non-saturated operation, the output load must be chosen so that the collector voltage of the output transistor is higher than the DC reference voltage, with all source current shunted into the output, for the particular bias levels used.

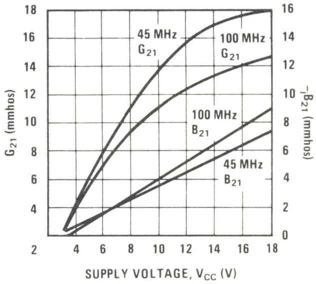
At some frequencies, bypassing of pins 3, 6, 7, or the V_{CC} connection may be required.



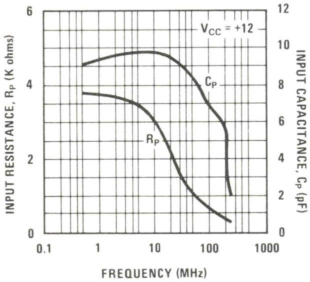
Input Resistance and Capacitance vs V_{CC}



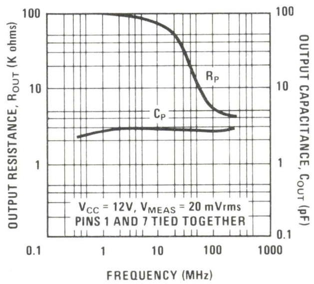
Output Resistance and Capacitance vs V_{CC}



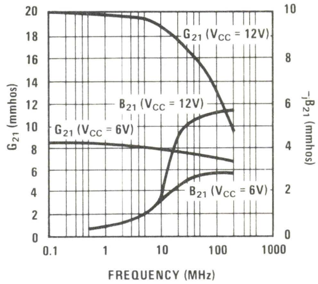
Forward Transadmittance vs V_{CC}



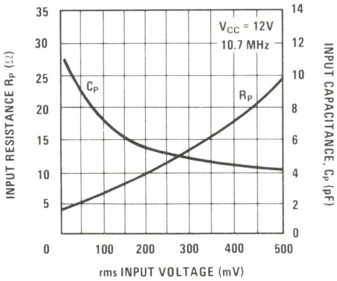
Input Resistance and Capacitance vs Frequency



Output Resistance and Capacitance vs Frequency



Forward Transadmittance vs Frequency



Input Resistance and Capacitance vs Input Signal Level

dc, audio and video configuration

Convenient self-contained biasing, excellent monolithic matching, and high gain-bandwidth product make a wide variety of applications possible using resistive loads.

The biasing shown in Figure 3 uses R2 as collector load for a single-ended output, differential input amplifier. By choosing the proper external load resistor, bias configuration, and supply voltage, video amplifiers may be constructed to meet specific gain and bandwidth requirements, in either cascode or emitter coupled form.

With matched pairs of external load resistors, true differential DC amplifiers may be constructed, with large common-mode input range, input offset voltages typically 0.3 mV, and monolithically matched, self-contained current sources easily tailored to specific operating point requirements.

Direct Coupled Test Circuit (Connect R_L Between Pins 8 and 10, or Connect Pin 2 to 8 for Internal R_L)

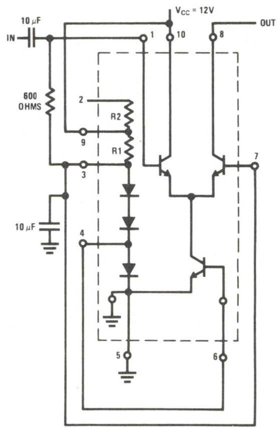
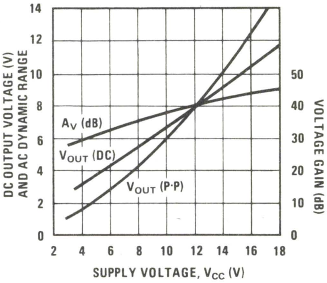
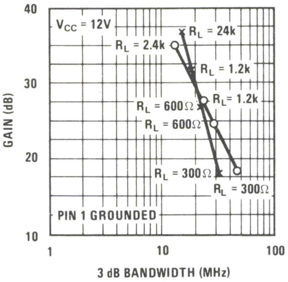


FIGURE 4

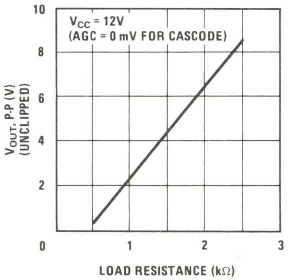
Voltage Gain, DC Output Voltage (R_L = R2) & Dynamic Range vs V_{CC}



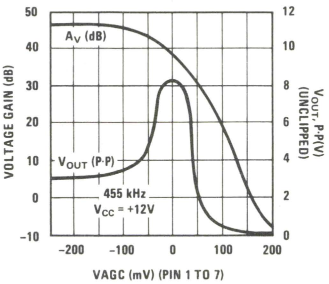
Cascode and Emitter Coupled Video Amplifiers Voltage Gain and Load Resistance vs Bandwidth



Cascode & Emitter Coupled Video Amplifiers Dynamic Range vs Load Resistance



Cascode Video Amplifier Voltage Gain & Dynamic Range vs AGC Voltage



Consumer Circuits

LM172/LM272/LM372 am if strip

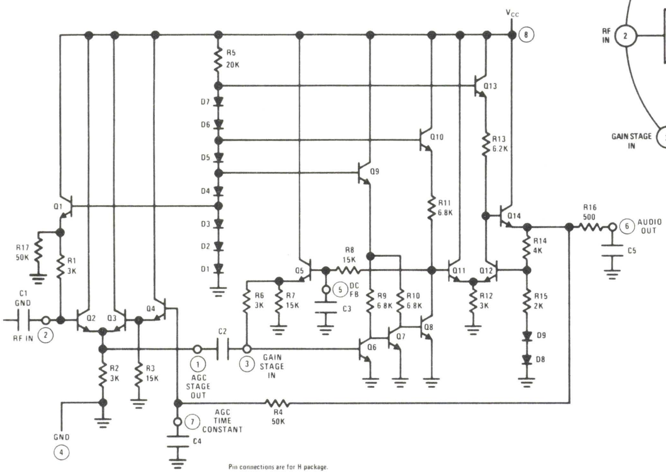
general description

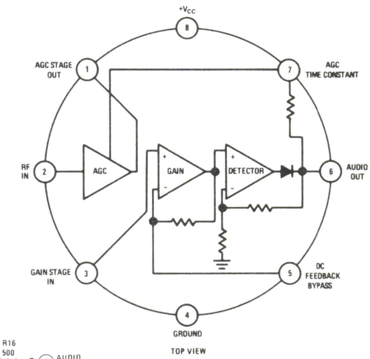
The LM172/LM272/LM372 is a broadband AM receiver subsystem, including a high gain amplifier, an active detector, and self-contained automatic gain control. It is intended for IF or TRF applications from 50 kHz to 2 MHz. Bandpass shaping is performed by a single, external filter, which may be ceramic, crystal, mechanical, or LC, having single or multiple poles. The IF strip features:

- AGC Range: 60 dB
- Audio Output of 0.8V p-p for 80% modulated inputs, at carrier levels as low as 50 μV rms.
- Total dissipation only 8.4 mW from +6V supply, usable with supply up to +15V.
- AGC time constant and audio frequency response selected by choice of external capacitors.
- Internal supply regulators eliminate individual stage decoupling.
- AGC voltage available to drive receiver "front end."

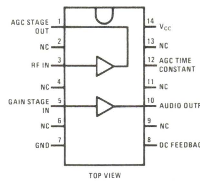
The LM172 is specified for operation over the −55°C to +125°C military temperature range. The LM272 is specified for operation over the −25°C to +75°C temperature range. The LM372 is specified for operation over the 0°C to +70°C temperature range.

schematic and connection diagrams



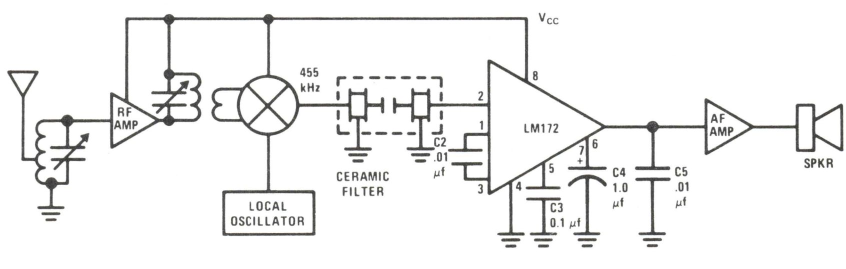


Order Number LM172H or LM272H or LM372H
See Package 11



Order Number LM272N or LM372N
See Package 22

typical application



absolute maxium ratings

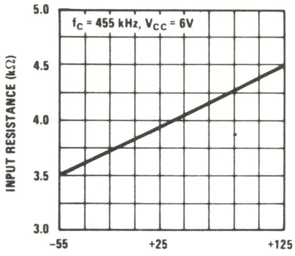
Supply Voltage Range		+6V to +15V
Storage Temperature		−65°C to +150°C
Operating Temperature	LM172	−55°C to +125°C
	LM272	−25°C to +75°C
	LM372	0°C to +70°C
RF Input Level, Pin 2		500 mV rms

electrical characteristics (T_A = 25°C)

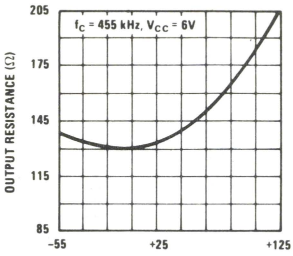
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply Drain	I_{ps}	V_{CC} = 6V, Input = 50 mV f = 455 kHz		1.4		mA
		V_{CC} = 6V, Input = 50 μV f = 455 kHz		1.7		mA
		V_{CC} = 15V, Input = 50 mV f = 455 kHz				
		LM172/272		2.5	2.65	mA
		LM372		2.5	3.2	mA
AGC Range	AGCR	V_{CC} = 6V, f = 455 kHz				
		LM172/272	50	69		dB
		LM372	47	69		dB
AGC Threshold	V_{IN}(th)	V_{CC} = 6V, f = 455 kHz		50		μV, rms
Maximum Usable Frequency	MUF	V_{CC} = 6V		2.0		MHz
Audio Output Voltage	V_{OUT}	V_{IN} Between 50 μV and 50 mV, 455 kHz, 80% modulated by 100 Hz,				
		V_{CC} = 6V				
		LM172/272	0.4	0.8		V, p-p
		LM372	0.35	0.8		V, p-p
		V_{CC} = 15V				
		LM172/272	0.45	0.9		V, p-p
		LM372	0.40	0.9		V, p-p

input-output impedance characteristics

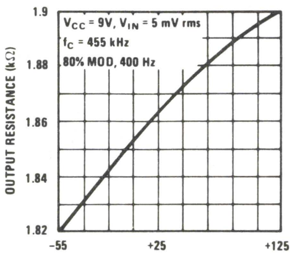
AGC Stage Input Resistance vs Temperature



AGC Stage Output Resistance vs Temperature

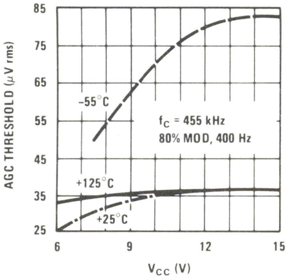


Detector Output Resistance vs Temperature

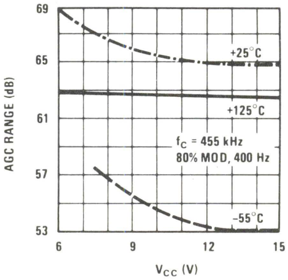


typical characteristics

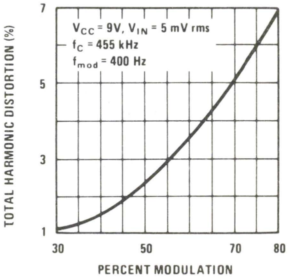
AGC Threshold vs V_{CC}



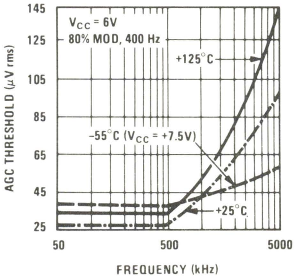
AGC Range vs V_{CC}



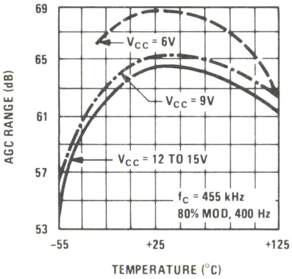
Audio Distortion vs % Modulation



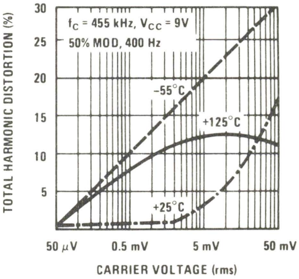
AGC Threshold vs Carrier Frequency



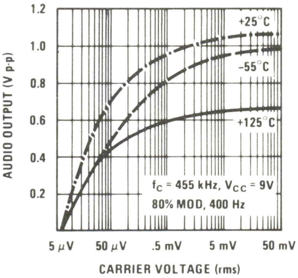
AGC Range vs Temperature



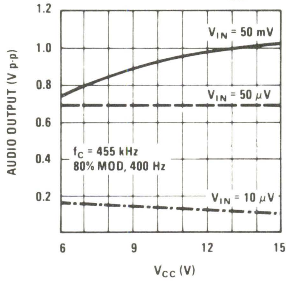
Audio Distortion vs Input Carrier Voltage



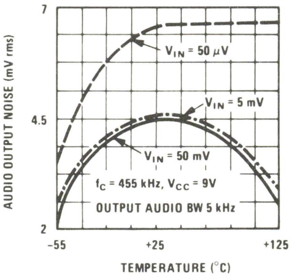
P-P Audio Output vs Input Carrier Voltage



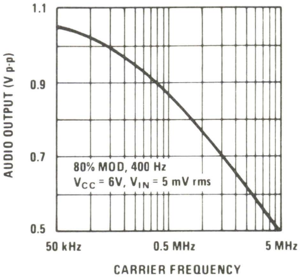
P-P Audio Output vs V_{CC}



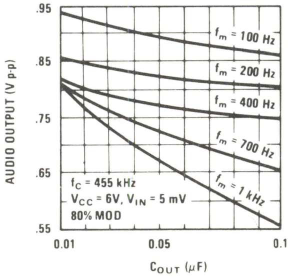
Audio Output Noise vs Temperature



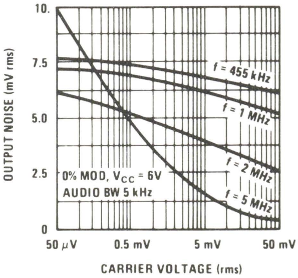
P-P Audio Output vs Carrier Frequency



P-P Audio Output vs Output Smoothing Capacitance

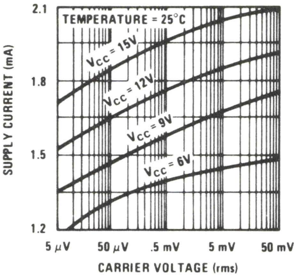


Audio Output Noise vs Input Carrier Voltage

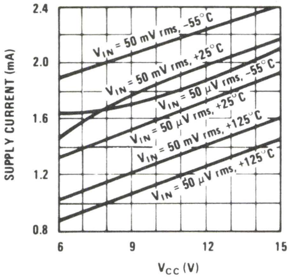


power supply characteristics

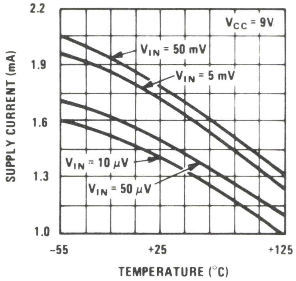
Power Supply Current vs Input Carrier Voltage



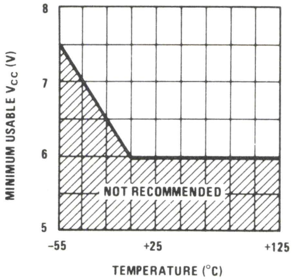
Power Supply Current vs V_{CC}



Power Supply Current vs Temperature



Minimum Operating V_{CC} vs Temperature



Consumer Circuits

LM273/LM373 am/fm/ssb if amp/detector
LM274/LM374 am/fm/ssb if video amp/detector

general description

The LM273/LM373 and LM274/LM374 are broadband communications subsystems, capable of performing the diverse functions required in AM, FM or single sideband receivers and transmitters. In addition, the LM274/LM374 may operate as high gain AGC'd video amplifier. Bandpass shaping may be performed by a single external filter, connected between amplifier sections, at frequencies from audio up to 30 MHz. The first section of the LM273/LM373 is optimized to drive low impedance loads, such as mechanical or ceramic filters. The LM274/LM374 has a high output impedance, ideal for high-Z crystal, LC or ceramic filters.

The LM273 and LM274 are specified for operation over the −25°C to +100°C military temperature range. The LM373 and LM374 are specified for operation over the 0°C to +70°C temperature range.

features

CONNECTED FOR AM OPERATION

- High gain; typical sensitivity of 10 μV at 455 kHz
- Wide bandwidth; 30 MHz capability
- Self-contained detector and AGC system
- Wide AGC range, greater than 60 dB for a 10 dB output change at 27 MHz
- Less than ±1 dB change in audio output −20°C to +100°C, typically
- Access to detector input for S/N improvement
- No DC paths required through external filters
- Low feedthrough between amplifier sections, typically better than 65 dB

CONNECTED FOR FM OPERATION

- Three emitter coupled limiting stages and simple quadrature detector
- Detection of ±5 kHz deviation FM at either 455 kHz or 10.7 MHz
- Two separated amplifier blocks, allowing filtering in two or more blocks
- No DC paths required through external filters or through quadrature network

CONNECTED FOR SSB OPERATION

- Double balanced product detector
- Self contained audio peak AGC system
- Easy external tailoring of AGC characteristic for desired AGC figure of merit

CONNECTED FOR VIDEO AMPLIFIER OPERATION

- Internal video peak detector for video AGC
- High and low level video outputs
- Gated video AGC capability

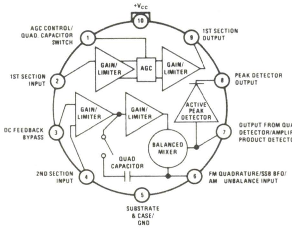
In addition, these versatile microcircuits may be used as:

- Constant amplitude or amplitude modulated RF oscillator
- Synchronous demodulating IF strip
- Mixer and IF, using AGC section as a mixer
- Double sideband modulator with audio AGC

5

connection diagrams

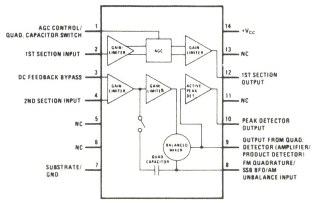
Metal Can Package



TOP VIEW

Order Number LM273H or LM373H
LM274H or LM374H
See Package 14

Dual-In-Line Package



TOP VIEW

Order Number LM373N or LM374N

See Package 22

absolute maximum ratings

Supply Voltage, Operating	18V	DC Voltage Applied to Any Other Pin	+8V, −0.5V
Supply Voltage, Surge (100 ms max)	24V	Junction Temperature (Note 1)	150°C
AC Voltage Applied to Any Pin	$1.4V_{p-p}$	Storage Temperature Range	−65°C to +150°C
DC Voltage Applied to AGC Section Output Pin		Operating Temperature Range	
LM273/LM373	+10V, −0.5V	LM273, LM274	−25°C to +100°C
LM274/LM374	+18V, −0.5V	LM373, LM374	0°C to +70°C

electrical characteristics

(T_A = 25°C, V_{CC} = +12V unless otherwise noted) (Subscript numbers in parentheses are DIP pin numbers)

DC CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	LM273/LM274 MIN	LM273/LM274 TYP	LM273/LM274 MAX	LM373/LM374 MIN	LM373/LM374 TYP	LM373/LM374 MAX	UNITS
Power Supply Current	$I_{10(14)}$	V_{CC} = 12V, AM Mode		14	20		14	20	mA
		$-20°C \leq T_A \leq +100°C$			21				mA
AGC Input Current	I_1	$V_{AGC} \leq 5V$		50	110		50	110	μA
		$-20°C \leq T_A \leq +100°C$			110				μA
AGC Section Quiescent Output	$V_{9(12)}$	V_{AGC} = 0V, LM273/LM373		4.75			4.75		V
	$I_{9(12)}$	V_{AGC} = 0V, LM274/LM374	0.5	0.7	1.0	0.5	0.7	1.0	mA
AGC Section Output Shift		V_{AGC} = 0V to V_{AGC} = 5V							
	$\Delta V_{9(12)}$	LM273/LM373		0.1			0.1		V
	$\Delta I_{9(12)}$	LM274/LM374		−0.1			−0.1		mA
Second Section Quiescent Output Voltage	$V_{7(9)}$			3.8			3.8		V
Peak Detector Quiescent Output Voltage	$V_{8(10)}$			3.8			3.8		V

VIDEO CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	LM273/LM274 MIN	LM273/LM274 TYP	LM273/LM274 MAX	LM373/LM374 MIN	LM373/LM374 TYP	LM373/LM374 MAX	UNITS
AGC Section Voltage Gain	$A_{2-9(11)}$	V_{AGC} = 0V, f = 455 kHz	30	32		29	32		dB
		V_{AGC} = 4.5V			−40			−40	dB
		$-20°C \leq T_A \leq 100°C$ LM273/LM373	28						dB
AGC Section Transconductance	$g_{m2-9(11)}$	V_{AGC} = 0V, f = 455 kHz	28	40		28	40		mmhos
		$-20°C \leq T_A \leq 100°C$ LM274/LM374	28						mmhos
AGC Section Bandwidth	BW_{AGC}	Z_L = 1k‖3 pF		30			30		MHz
AGC Section Output Swing	$V_{9(12)}\ max_{p-p}$	R_L = 1k, V_{AGC} = 0V, V_2 = ±300 mV,	0.95	1.4		0.78	1.4		V_{p-p}
		$-20°C \leq T_A \leq 100°C$	0.7						V_{p-p}
AGC Section Conversion Voltage Gain	$A_{C, AGC}$	f_1 = 30 MHz, f_2 = 30.455 MHz, e_2 = 800mVrms (See Figure 8)		22			22		dB
Second Section Voltage Gain	$A_{4-7(11)}$	f = 455 kHz	32.5	37	39	29.5	37	–	dB
		T_A = 100°C		31					
Second Section Bandwidth	BW_2	Z_L = 100k ‖ 3 pF		20			20		MHz
Second Section Output Swing	$V_{7(11)}\ max_{p-p}$	V_{3-4} = ±100 mV_{p-p}	0.93	1.4		.83	1.4		V_{p-p}
		$-20°C \leq T_A \leq 100°C$	0.75						V_{p-p}

AC PORT PARAMETERS (Typical, e_{IN} = 20 mVrms)

TERMINAL	LM273/LM373 f = 455 kHz	LM273/LM373 f = 10.7 MHz	LM273/LM373 f = 27 MHz	LM274/LM374 f = 455 kHz	LM274/LM374 f = 10.7 MHz	LM274/LM374 f = 27 MHz
2 (V_{AGC} = 0V)	1.2k ‖ 2.5 pF	1.2k ‖ 2.5 pF	1.15k ‖ 2.6 pF	1.2k ‖ 2.5 pF	1.2k ‖ 2.5 pF	1.15k ‖ 2.6 pF
2 (V_{AGC} = 5V)	1.18k ‖ 3 pF	1.18k ‖ 3 pF	1.1k ‖ 2.7 pF	1.18k ‖ 3 pF	1.18k ‖ 3 pF	1.1k ‖ 2.7 pF
4	4.5k ‖ 4 pF	5k ‖ 5 pF	4.3k ‖ 5.5 pF	4.5k ‖ 4 pF	5k ‖ 5 pF	4.3k ‖ 5.5 pF
6(8)	3.0k ‖ 7.7 pF	3.0k ‖ 7.7 pF	3.0k ‖ 8.0 pF	3.0k ‖ 7.7 pF	3.0k ‖ 7.7 pF	3.0k ‖ 8.0 pF
7(9)	1.0k ‖ 6 pF	1.0k ‖ 6 pF	1.0k ‖ 5 pF	1.0k ‖ 6 pF	1.0k ‖ 6 pF	1.0k ‖ 5 pF
9(12)	70Ω ‖ −100 pF	60Ω ‖ 5 pF	200Ω ‖ −90 pF	600k ‖ 5.5 pF	100k ‖ 3.3 pF	10k ‖ 3.5 pF

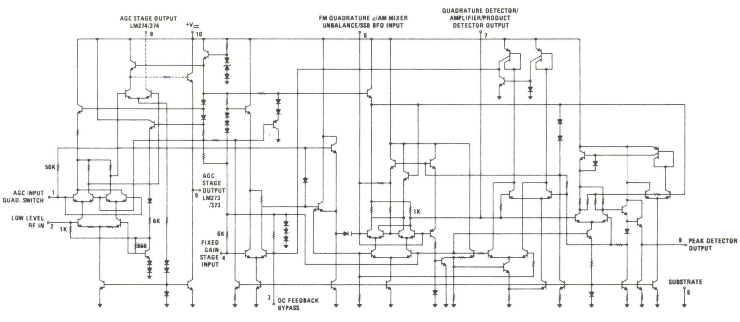
Note 1: For operation at elevated temperatures, derate devices based on 150°C maximum junction temperature and 150°C/W junction to ambient or 45°C/W junction to case thermal coefficients for the metal can.

electrical characteristics (con't)

TYPICAL AM PERFORMANCE (See Figures 1 and 2)

PARAMETER	CONDITIONS	f = 455 kHz	f = 10.7 MHz	f = 27 MHz	UNITS
Sensitivity	(Signal + Noise)/Noise = 10 dB	10	15	30	μVrms
AGC Threshold	Output 3 dB below extrapolated low level gain curve value for same input	35	55	110	μVrms
AGC Figure of Merit	Number (dB) input change from 100 mVrms for 10 dB output change	68	63	60	dB
Gain Control Range	V_1 = 0 to V_1 = +5V	80	70	66	dB
Audio Output	R_{AGC} = 2.4k, V_{IN} 100 mVrms f_m = 1 kHz, m = 0.7	100	100	100	mVrms
	As above, T_A = 100°C LM273 and LM274 only	90	90	90	mVrms
Signal to Noise Ratio	M = 0.7 to M = 0 e_{IN} = 30 mVrms	42	38	40	dB
Audio Distortion	M = 0.7, f_m = 1 kHz, e_{IN} = 10 mV	5	3.5	2.8	%
TYPICAL FM PERFORMANCE (See Figures 3 and 4)					
Limiting Threshold	e_O = 3 dB from value at e_{IN} = 100 mVrms				
	Δf = ±75 kHz		800	–	μVrms
	Δf = ±5 kHz	800	800	–	μVrms
AM Rejection Ratio	M_{fm} = 1, M_{am} = 0.3 e_{IN} = 10 mVrms				
	Δf = ±75 kHz		45	–	dB
	Δf = ±5 kHz	35		–	dB
Audio Output	e_{IN} = 10 mVrms				
	Δf = ±75 kHz		80	–	mVrms
	Δf = ±5 kHz	70	38	–	mVrms
	@ T_A = 100°C, Δf = ±75 kHz		50	–	mVrms
	@ T_A = 100°C, Δf = ±5 kHz LM273 and LM274 only	40	19	–	mVrms
Audio Distortion	e_{IN} = 10 mVrms				
	Δf = ±75 kHz		1.5	–	%
	Δf = ±5 kHz	2	1.0	–	%
TYPICAL SSB PERFORMANCE (See Figures 5 and 6)					
Sensitivity	(Signal + Noise)/Noise = 10 dB e_{LO} = 60 mVrms	25	30	60	μVrms
AGC Threshold	Same as AM	300	300	500	μVrms
AGC Figure of Merit	Same as for AM	60	60	50	dB
Audio Output Voltage	e_{IN} = 100 mVrms	60	80	85	mVrms
	T_A = 100°C LM273 and LM274 only	40	55	60	mVrms

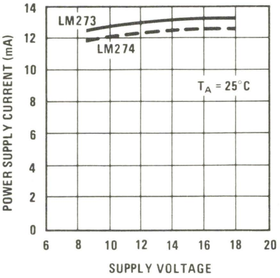
schematic diagram



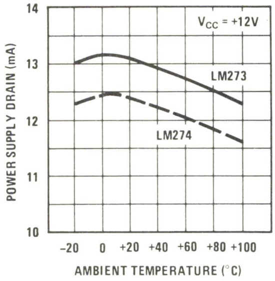
Pin connections shown are for TO-5 package only.

typical performance characteristics

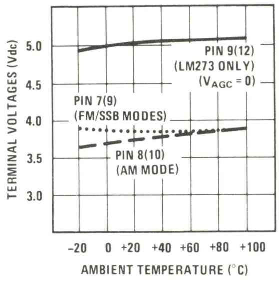
Power Supply Current vs Supply Voltage



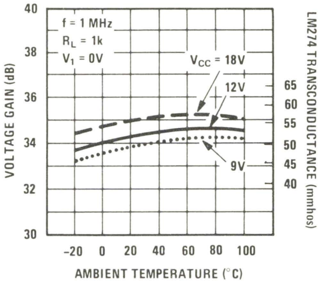
Power Supply Current vs Ambient Temperature



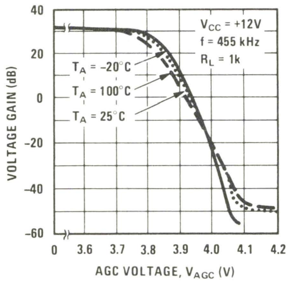
Output Terminal Voltage vs Temperature



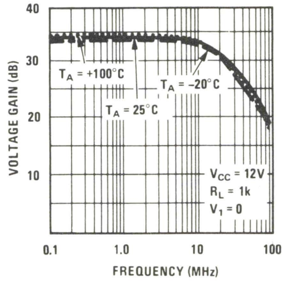
First Section Voltage Gain or Transconductance vs Temperature



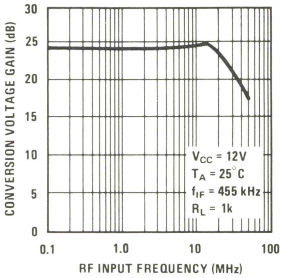
First Section Voltage Gain vs AGC Voltage



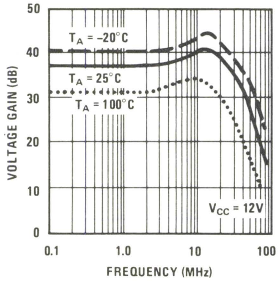
First Section Voltage Gain vs Frequency



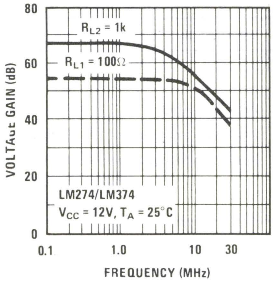
First Section Conversion Voltage Gain vs Frequency



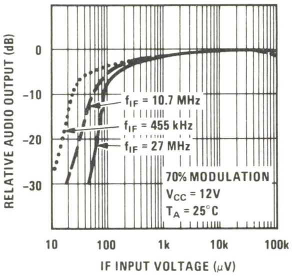
Second Section Voltage Gain vs Frequency



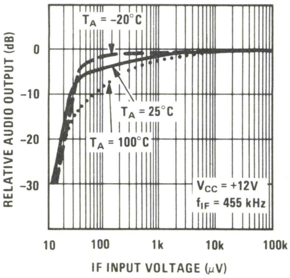
Cascaded Sections Video Gain vs Frequency, LM274/LM374 Only



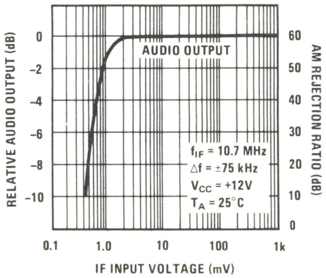
AM IF Audio Output vs IF Input Voltage



Relative AM Audio Output vs IF Input Voltage, Referred to 100 mV Inputs

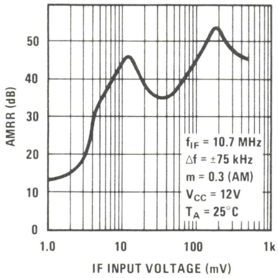


Wide Band FM Audio Output vs IF Input Voltage

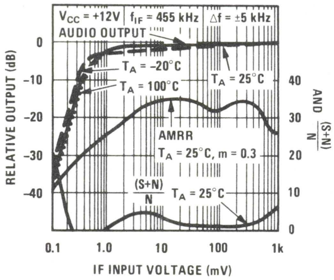


typical performance characteristics (con't)

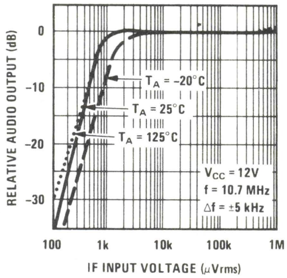
AM Rejection Ratio vs IF Input Voltage for Wide Band FM



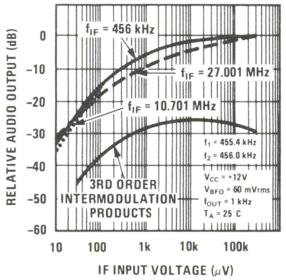
455 kHz NFM IF Audio Output, AM Rejection Ratio, and Signal to Noise vs IF Input Voltage



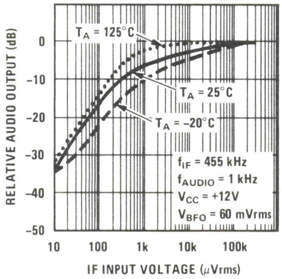
10.7 MHz NFM IF Audio Output vs IF Input Voltage



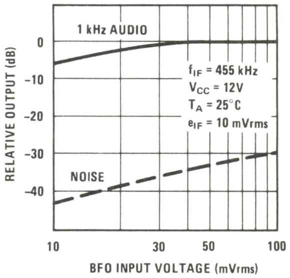
SSB IF Audio Output and Intermodulation Products vs IF Input Level



SSB IF Audio Output vs IF Input Voltage



SSB IF Audio Output vs BFO Voltage



APPLICATION HINTS

The LM273/LM373 and LM274/LM374 devices have been designed for stability and minimum usage of external components, while at the same time offering wide versatility through access to inputs and outputs of nearly every major functional block of the device. This makes possible the detection of AM, FM, and SSB signals with a single device with a minimum of circuitry switching. Experience has shown that for optimum performance of the multiple mode IF strip, the following suggestions should be noted.

First, as with any radio frequency gain device, proper layout and minimum lead length should be observed. The first gain block, Pin 2 to Pin 9, shows a typical gain of 32 dB and the second gain block, Pin 4 to Pin 7, shows a typical gain of 37 dB so it is clear why any stray coupling or long leads should be kept clear from any of the gain input pins. Despite it's high gain, however, the device does not require any shielding between stages. Construction on a copperclad printed circuit type board is more than adequate. It should also be observed that good power supply bypassing directly at Pin 10 and DC feedback bypassing at Pin 3 is always necessary.

The devices can be wide-band coupled to provide video gain response up to approximately 50 MHz. For AM operation, however, it is much more desirable to limit the IF bandwidths. This will greatly increase both input sensitivity and AGC figure of merit by preventing the device from AGCing on wideband detected noise. There are two ways of accomplishing this. One is to insert filtering from the first gain block to the second, Pin 9 to Pin 4, but the most effective way is to AC couple an L-C tank from the input of the active peak detector to ground. A lossy filter from Pin 9 to Pin 4 should be avoided as this will greatly reduce the audio output and AGC figure merit. In addition the tank on Pin 7 should have high enough Q to limit noise yet low enough to pass the full IF signal. It should also have a high enough impedance (>5k) to avoid affecting the gain of that stage. Proper audio output is attained by a small capacitor at Pin 8 to peak detect the RF envelope, followed by a series RC roll off to shape the audio response. Here again excessive loading will reduce available output. There is a trade off available between audio level out and AGC range so the feedback resistor from Pin 8 to the AGC feedback, Pin 1, should be adjusted to give the desired results. Pin 1 must

be filtered well with approximately 15 μF capacitor or larger to prevent any AC variation from causing erratic AGC action.

For proper FM operation, the input level needs to be larger, on the order of 1 mV to give full limiting which is necessary for good AM rejection. Here again low loss coupling from Pin 9 to Pin 4 is desired. The phase shift network on Pin 6 should be shielded to prevent any extraneous RF pickup or radiation. Also the Q of the network should be adjusted to give the proper bandwidth for the type of signal to be detected, whether wideband or narrowband FM. Obviously, it should be tuned to the same center frequency as the IF input and the Pin 9 to Pin 4 filtering so that detection takes place symmetrically around the resonant frequency of the tank. Since the audio output for FM is at Pin 7, it should be RF bypassed along with audio rolloff and de-emphasis.

For SSB operation, the devices operate almost the same as in the AM mode, with the exception that the product detector which was unbalanced and used as a simple gain stage for AM is now balanced and used for detection. The local oscillator signal is fed into Pin 6 at an optimum level around 60 mVrms. For better AGC, a capacitor may be added to Pin 8 in addition to the one already at Pin 1 to provide even more filtering for AGC feedback voltage. The output level and AGC figure of merit is still adjusted by the feedback resistors from Pin 8 to Pin 1.

typical applications

*Capacitors noted by asterisk are 0.1 at 455 kHz. L is Miller No. 43A105CBI for 455 kHz; 8 turns No. 26 AWG on Micrometals T25-2 Carbonyle Core (.255 OD x .180 ID x .096W) for 10.7 MHz; 3-1/2 turns No. 20 AWG 5/16" dia x 1/4" long for 27 MHz.

f	C1	C2	C3	C4	L
455 kHz	.01	1000	.012	.001	10.5 µH
10.7 MHz	1000	250	1000	500	.22 µH
27 MHz	1000	180	300	500	.12 µH

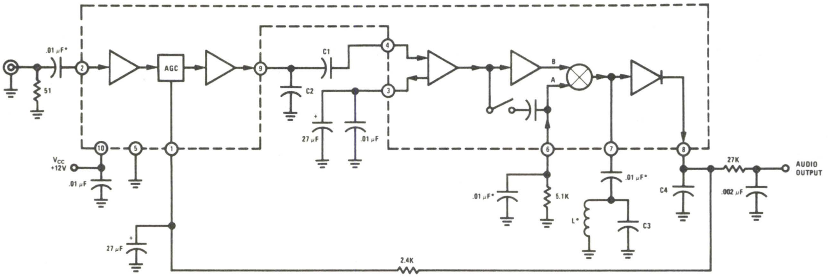
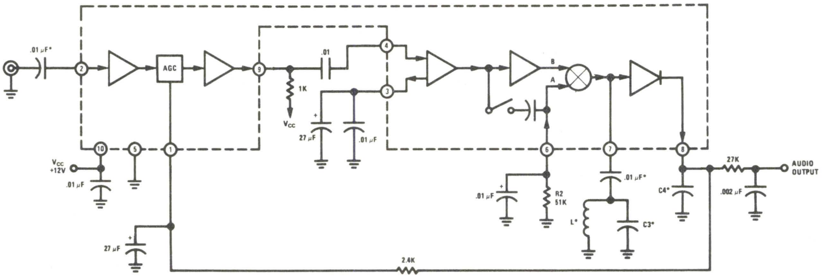


FIGURE 1. LM273/LM373 AM IF Connection



*See Figure 1 for component values.

FIGURE 2. LM274/LM374 AM IF Connection

T Pri 5 turns No. 32, sec 30 turns No. 32, Core Micrometals T25-2 (Ref. Figure 1).

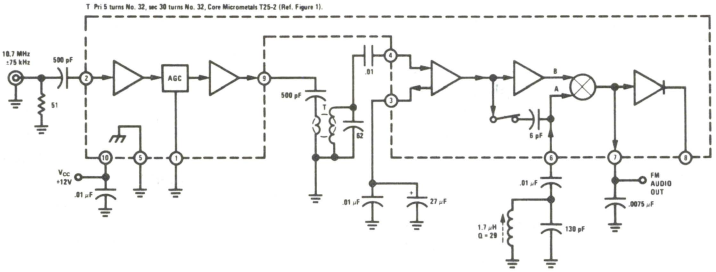


FIGURE 3. LM273/LM373 Wide Band FM IF Connection

typical applications (con't)

*For 455 kHz, T is 8t & 60t No. 36 AWG on Micrometals T25-3 Core (Carbonyl HP, .255 OD x .120 ID x .096W); L is 680 turns universal wound No. 38 enamel with 10-32 x 1/4" Carbonyl HP core. For 10.7 MHz, T is 5t & 30t of No. 32 AWG on Micrometals T25-2 Core; L is 37t No. 36 AWG on .200 dia form with 10-32 x 1/4" Carbonyl E Core (Q_{AV} = 170).

f	C1	R	C2	C3	C4	C5	C6
455 kHz	500	0	.1	.05	5000	33	150
10.7 MHz	.01	300	.01	500	43	47	82

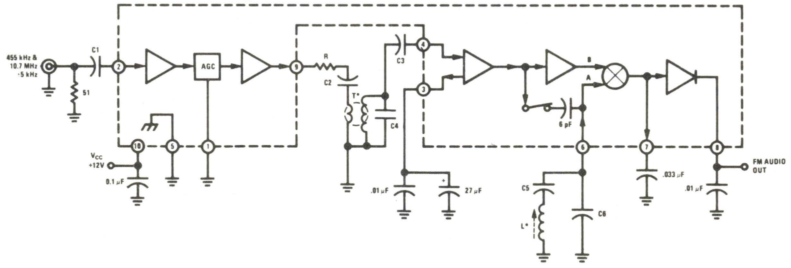


FIGURE 4. LM273/LM373 Narrow Band FM IF Connection

f	C1	C2
455 kHz	1000	.005
10.7 MHz	250	1000
27 MHz	180	1000

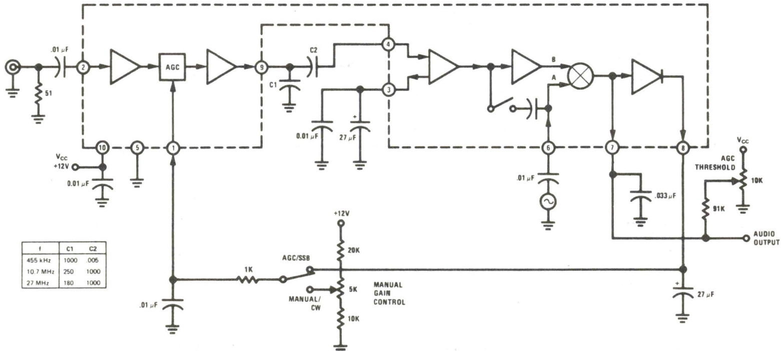


FIGURE 5. LM273/LM373 SSB & CW IF Connection

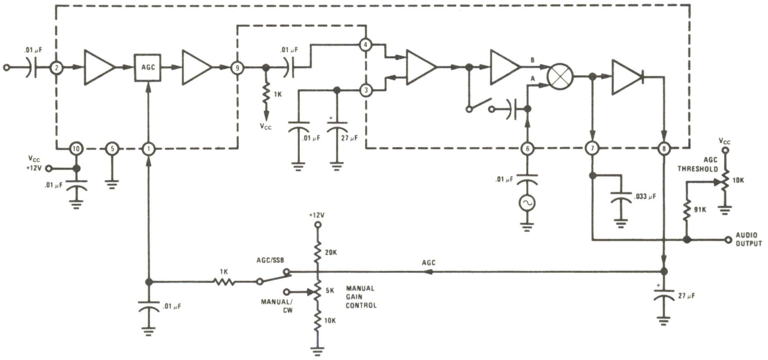


FIGURE 6. LM274/LM374 SSB & CW IF Connection

5

typical applications (con't)

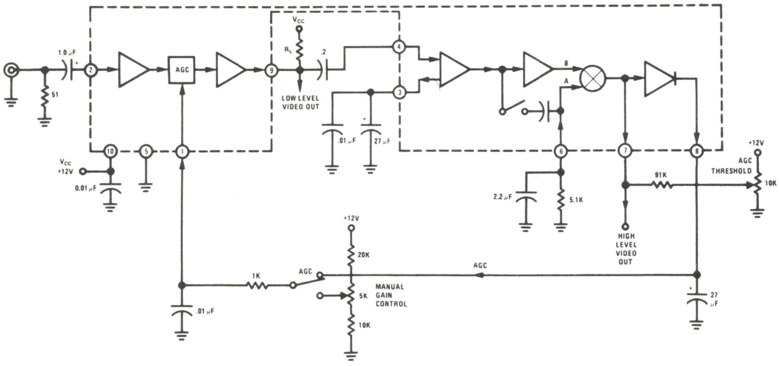


FIGURE 7. LM274/LM374 Video Amplifier Configuration

*Capacitors noted by asterisk are 0.1 at 455 kHz. L is Miller No. 43A105CBI for 455 kHz; 8 turns No. 26 AWG on Micrometals T25-2 Carbonyle Core (.255 OD x .180 ID x .096W) for 10.7 MHz; 3-1/2 turns No. 20 AWG 5/16" dia x 1/4" long for 27 MHz.

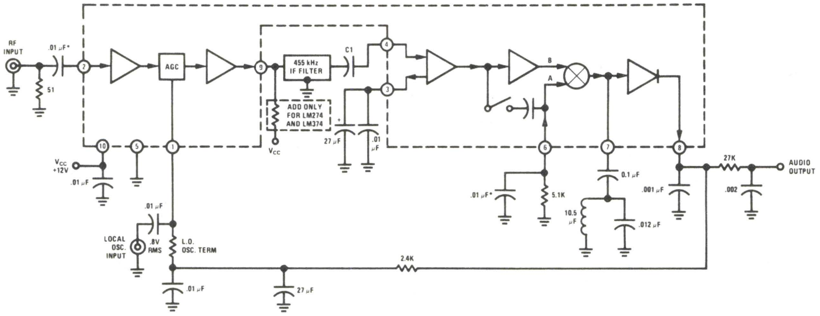


FIGURE 8. LM274/LM374, LM273/LM373 First Stage Converter Operation for AM Signal Detection @ 455 kHz

Consumer Circuits

LM175/LM275/LM375 oscillator and buffer with TTL output

general description

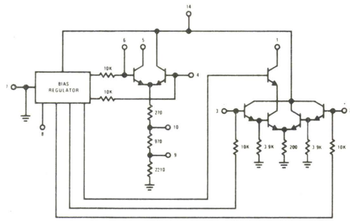
The LM175/LM275/LM375 is a monolithic, differential pair, general purpose oscillator. It may be used with crystal control or with LC or RC tanks. Two output configurations are possible. It may be connected to the internal isolating buffer to provide sine or square wave outputs, or to the internal logic buffer with output levels and switching times compatible with TTL and DTL logic circuitry. It provides extremely high temperature and power supply versus frequency rejection.

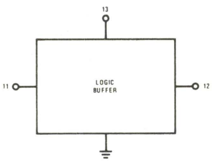
The LM175 is specified for operation over the −55°C to +125°C military temperature range. The LM275 is specified for operation over the −25°C to +85°C temperature range. The LM375 is specified for operation over the 0°C to +70°C temperature range.

features

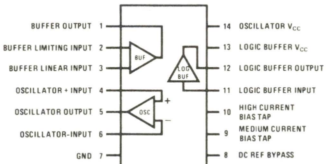
- Oscillation up to 200 MHz
- Operation from supplies from 4.5V to 24V (Logic buffer maximum supply at 7.0V)
- High supply voltage rejection, typically 0.1 ppm/V
- Low temperature coefficient, typically 0.05 ppm/°C
- Variable drive to crystal to limit dissipation
- Capable of fundamental or overtone, series or parallel mode of operation
- Separate power supply lead for logic buffer for noise isolation
- Low power dissipation

schematic and connection diagrams





Dual-In-Line Package



TOP VIEW

Order Number LM175D or LM275D or LM375D
See Package 1

Order Number LM375N
See Package 22

typical applications

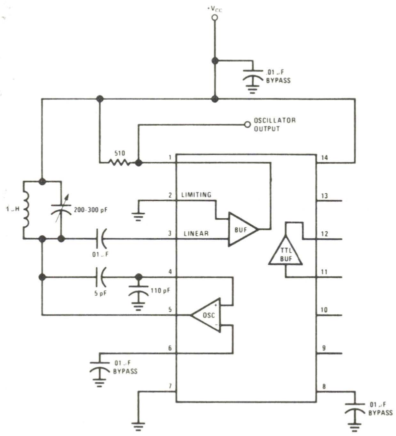


FIGURE 1. 10 MHz L–C Sine Wave Oscillator

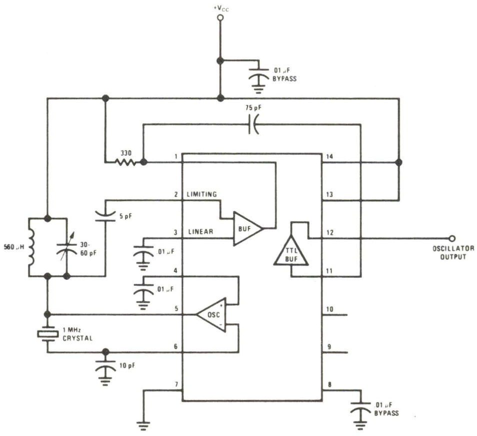


FIGURE 2. 1 MHz Crystal Oscillator with TTL Output

absolute maximum ratings

Supply Operating Voltage (Pin 14)	24V
Supply Operating Voltage (Pin 13)	7V
Differential Input Voltage ΔV P_4 to Pin 6	5V
ΔV P_2 to Pin 3	5V
Power Dissipation (Note 1)	500 mW
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range LM175	−55°C to +125°C
LM275	−25°C to +85°C
LM375	0°C to 70°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V_{CC} = 5V unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
Power Supply Current (Pin 14)	I_{PS14}	V_{CC} = 24V	4.0	6.0	12.0	mA
Power Supply Current (Pin 13)	I_{PS13}	No Load at Pin 12	4.0	6.0	14.0	mA
Oscillator Output Current	I_{OSC}	R_L (Pin 5) = 1 kΩ				
		Pin 9 Open, Pin 10 Open	120	140		μA_{p-p}
		Pin 9 Tied to Pin 10	160	190		μA_{p-p}
		Pin 9 Grounded, Pin 10 Open	300	360		μA_{p-p}
		Pin 10 Grounded, Pin 9 Open	750	1000		μA_{p-p}
Buffer Output Current	I_{BUF}		2.5	3.0		mA_{p-p}
Logic Buffer Output Voltage	V_{TTL}	Input LOW	2.1	2.7		
		Input HIGH				
		I_{SINK} = 1.6 mA		200	400	mV
The Following Specifications apply to −55°C < T_A < +125°C						
Oscillator Output Current	I_{OSC}	R_L (Pin 5) = 1 kΩ				
		Pin 9 Open, Pin 10 Open	100			μA_{p-p}
		Pin 9 Tied to Pin 10	130			μA_{p-p}
		Pin 9 Grounded, Pin 10 Open	250			μA_{p-p}
		Pin 10 Grounded, Pin 9 Open	600			μA_{p-p}
Buffer Ouptut Current	I_{BUF}		2.0			mA_{p-p}
AC CHARACTERISTICS						
Oscillator Gain (at 1 kHz)	gm_{OSC}	Pin 9 Open, Pin 10 Open		1.4		mmhos
		Pin 9 Tied to Pin 10		1.9		mmhos
		Pin 9 Grounded, Pin 10 Open		3.6		mmhos
		Pin 9 Open, Pin 10 Grounded		10.0		mmhos
Oscillator 3 dB Bandwidth	BW_{OSC}	$R_S = R_L$ (Pin 5) = 50Ω		200		MHz
Buffer Gain (at 1 kHz)	gm_{BUF}	R_L (Pin 1) = 500Ω				
		Linear Mode		8		mmhos
		Limiting Mode		30		mmhos
Buffer 3 dB Bandwidth	BW_{BUF}	$R_S = R_L$ (Pin 1) = 50Ω				
		Linear Mode		200		MHz
		Limiting Mode		80		MHz
Logic Buffer Rise Time				20	50	ns
Logic Buffer Fall Time				20	50	ns

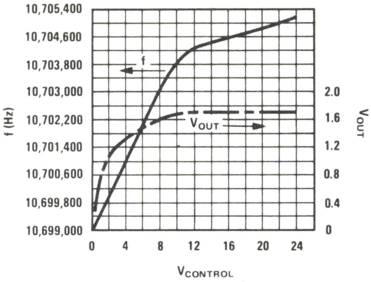
Note 1: For operation at elevated temperatures, the device must be operated based on a 150°C maximum junction temperature with a thermal resistance of 140°C/W for the metal DIP package and 100°C maximum junction temperature with a thermal resistance of 150°C/W for the plastic DIP package.

electrical characteristics (con't)

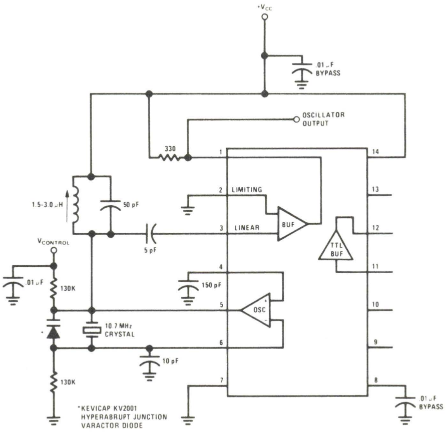
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
OSCILLATOR CHARACTERISTICS (See Oscillator Circuit)						
Frequency vs Power Supply Rejection		$5V < V_{CC} < 10V$		0.1		ppm/V
Frequency vs Temperature Rejection		$-55°C < T_A < +125°C$		0.05		ppm/°C
Load Pull (Change in Frequency vs Change in Buffer Load Impedance)		$0 \leq R_{L\ BUF} \leq \infty$		0.01		ppm
INPUT-OUTPUT TERMINAL CHARACTERISTICS						
Oscillator Input Resistance	R_4	Minimum Current Maximum Current		10 4.5		kΩ kΩ
	R_6	Minimum Current Maximum Current		10 4.5		kΩ kΩ
Oscillator Input Capacitance	C_4 C_6			3 3		pF pF
Oscillator Output Resistance	R_5	Minimum Current Maximum Current		100 30		kΩ kΩ
Oscillator Output Capacitance	C_5			3		pF
Buffer Input Resistance	R_2 R_3			10 10		kΩ kΩ
Buffer Input Capacitance	C_2 C_3			2 2		pF pF
Buffer Output Resistance	R_1			100		kΩ
Buffer Output Capacitance	C_1			5		pF
Logic Buffer Input Resistance	R_{11}			1.2		kΩ
Logic Buffer Input Capacitance	C_{11}			4		pF

typical oscillator circuit connections

Frequency and Output Voltage for Parallel Tuned VCXO

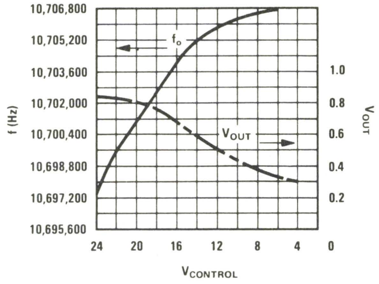


10.7 MHz Voltage-Controlled Crystal Oscillator Parallel Tuning

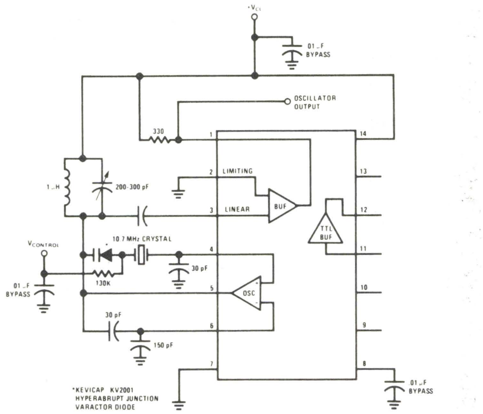


typical oscillator circuit connections (con't)

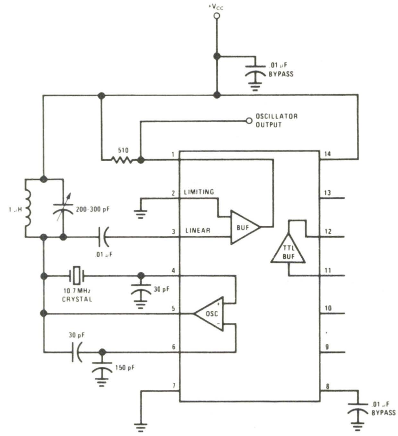
Frequency and Output Voltage for Series Tuned VCXO



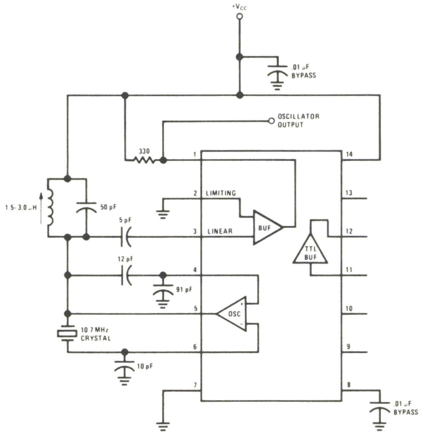
10.7 MHz Voltage Controlled Crystal Oscillator Series Tuning



10.7 MHz Series Resonant Crystal Oscillator

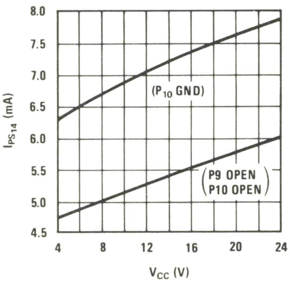


10.7 MHz Parallel Resonant Crystal Oscillator

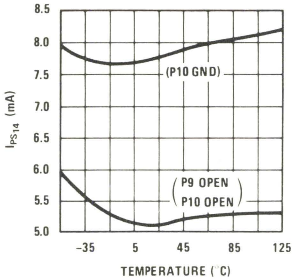


typical performance characteristics

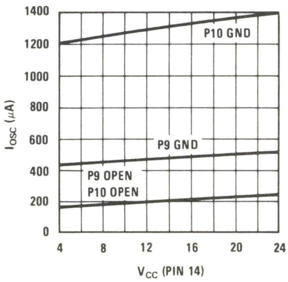
I_{PS14} vs V_{CC} ($T_A = 25°C$)



I_{PS14} vs Temperature (V_{CC} = 12V)

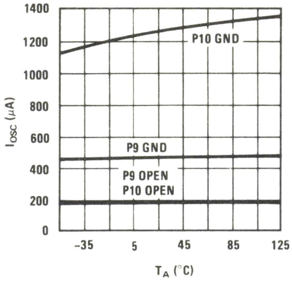


I_{OSC} vs V_{CC} $T_A = 25°C$

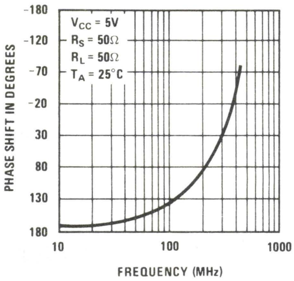


typical performance characteristics (con't)

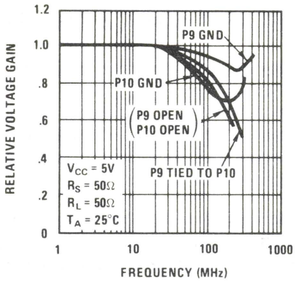
I_{OSC} vs Temperature
V_{CC} = 12V



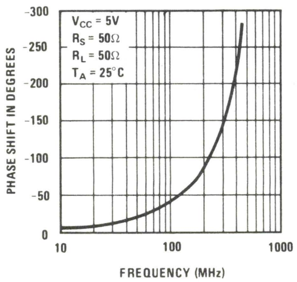
Phase Shift from Pin 6 to Pin 5



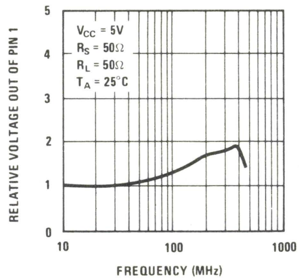
OSC Stage Bandwidth



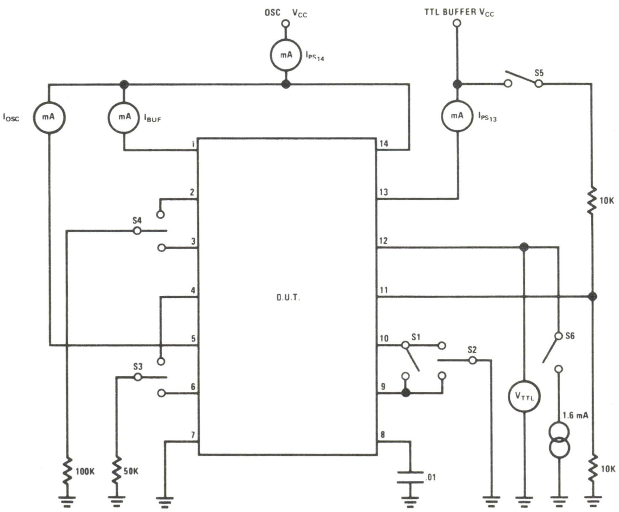
Phase Shift from Pin 4 to Pin 5



OSC Buffer Bandwidth



dc test circuit



S1, S2 Used to select desired oscillator current
S3 Used to swing oscillator output and measure I_{OSC}.
S4 Used to swing buffer output and measure I_{BUF}.
S5 Used to switch TTL buffer to high and low states
S6 Switches in maximum guaranteed TTL load to measure V_{TTL} in the low state

Consumer Circuits

LM377 dual 2 watt audio amplifier

general description

The LM377 is a monolithic dual power amplifier which offers high quality performance for stereo phonographs, tape players, recorders, and AM-FM stereo receivers, etc.

The LM377 will deliver 2W/channel into 8 or 16Ω loads. The amplifier is designed to operate with a minimum of external components and contains an internal bias regulator to bias each amplifier. Device overload protection consists of both internal current limit and thermal shutdown.

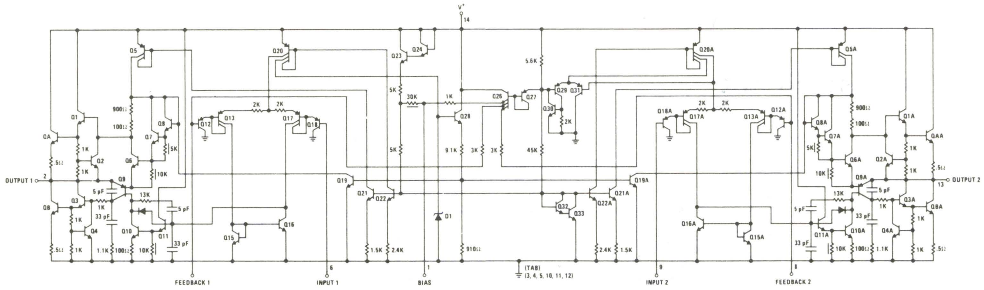
features

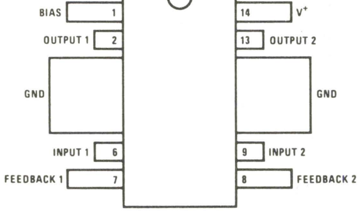
- A_{VO} typical 90 dB
- 2W per channel
- 80 dB ripple rejection
- 75 dB channel seperation
- Internal stabilization
- Self centered biasing
- 3 MΩ input impedance
- 10 – 26V operation
- Internal current limiting
- Internal thermal protection

applications

- Multi-channel audio systems
- Tape recorders and players
- Movie projectors
- Automotive systems
- Stereo phonographs
- Bridge output stages
- AM-FM radio receivers
- Intercoms
- Servo amplifiers
- Instrument systems

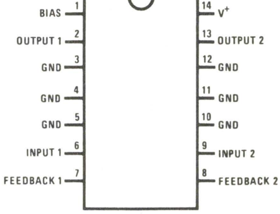
schematic and connection diagrams





TOP VIEW

Order Number LM377N-10
See Package 30



TOP VIEW

Order Number LM377N
See Package 22

absolute maximum ratings

Supply Voltage	26V
Input Voltage	0V to V_{SUPPLY}
Operating Temperature	0°C to +70°C
Storage Temperature	−65°C to +150°C
Junction Temperature	150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

V_S = 20V, T_{TAB} = 25°C, R_L = 8Ω, A_V = 50 (34 dB), unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Total Supply Current	P_{OUT} = 0W		15	50	mA
	P_{OUT} = 1.5W/Channel		430	500	mA
DC Output Level			10		V
Supply Voltage		10		26	V
Output Power	T.H.D. = < 5%	2	2.5		W
T.H.D.	P_{OUT} = 0.05W/Channel, f = 1 kHz		0.25		%
	P_{OUT} = 1W/Channel, f = 1 kHz		0.07	1	%
	P_{OUT} = 2W/Channel, f = 1 kHz		0.10		%
Offset Voltage			3		mV
Input Bias Current			500		nA
Input Impedance		3			MΩ
Open Loop Gain	R_S = 0Ω	66	90		dB
Output Swing			V_S−6		V_{P-P}
Channel Separation	C_F = 250μF, f = 1 kHz	50	70		dB
Ripple Rejection	f = 120 Hz, C_F = 250μF	60	80		dB
Current Limit			1.5		A
Slew Rate			1.4		V/μs
Equivalent Input Noise Voltage	R_S = 600Ω, 100 Hz − 10 kHz		3		μVrms

Note 1: For operation at ambient temperatures greater than 25°C the LM377 must be derated based on a maximum 150°C junction temperature using a thermal resistance which depends upon device mounting techniques.

Note 2: Dissipation characteristics are shown for four mounting configurations.

a. Infinite sink − 13.4°C/W

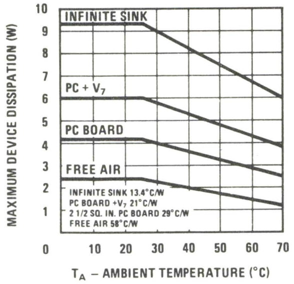
b. P.C. board $+V_7$ sink − 21°C/W. P.C. board is 2 1/2 square inches. Staver V_7 sink is 0.02 inch thick cooper and has a radiating surface area of 10 square inches.

c. P.C. board only − 29°C/W. Device soldered to 2 1/2 square inch P.C. board.

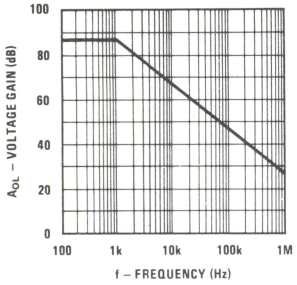
d. Free air − 58°C/W.

typical performance characteristics

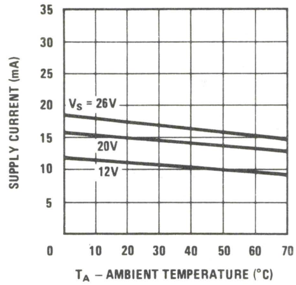
Maximum Dissipation vs Ambient Temperature



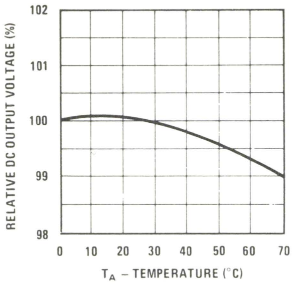
Open Loop Gain



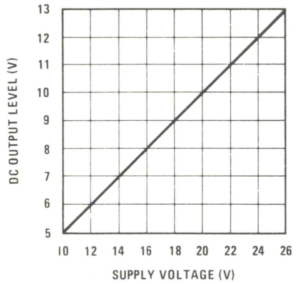
Supply Current vs Temperature



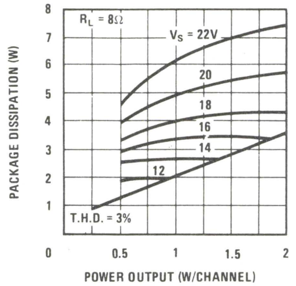
DC Output Level vs Temperature



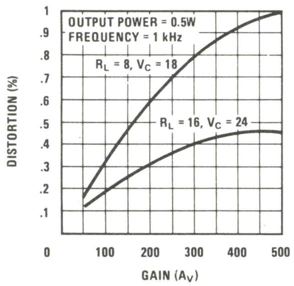
DC Output Level vs V_S



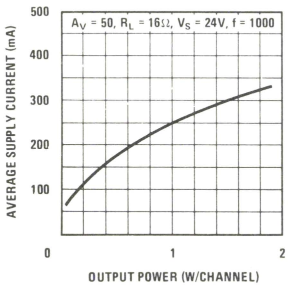
Power Dissipation vs Power Output



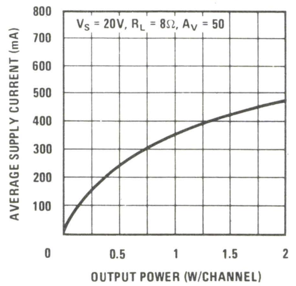
Distortion vs Gain



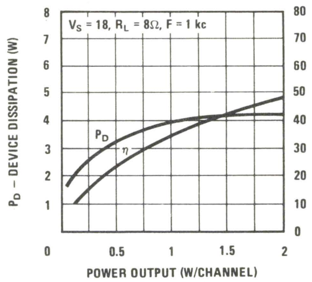
Supply Current vs Output Power



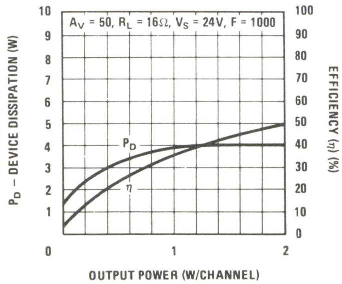
Supply Current vs P_{OUT}



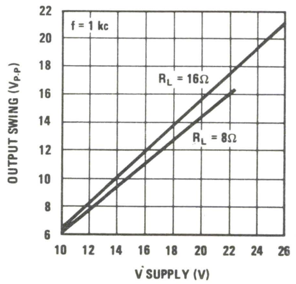
Dissipation and Efficiency vs P_{OUT}



Dissipation and Efficiency vs P_{OUT}

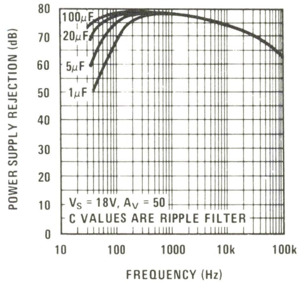


Output Swing vs V_S

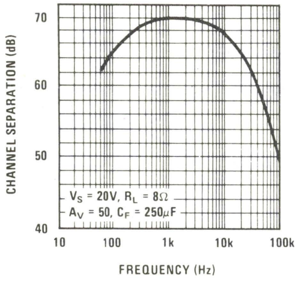


typical performance characteristics (con't)

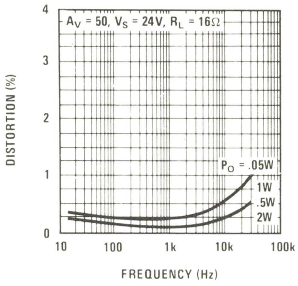
Supply Rejection vs Frequency



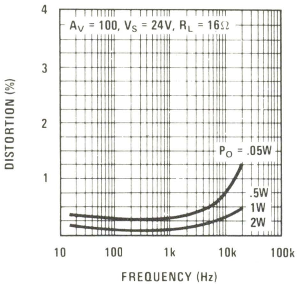
Channel Separation



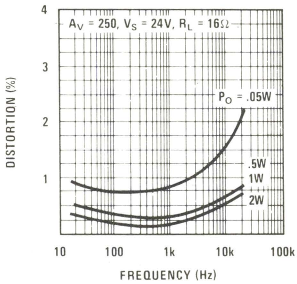
Distortion vs Frequency



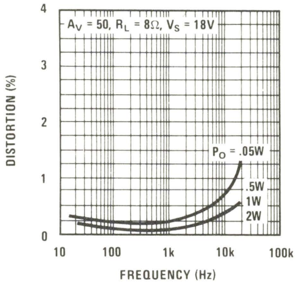
Distortion vs Frequency



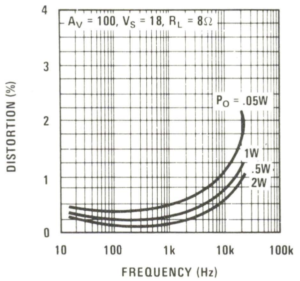
Distortion vs Frequency



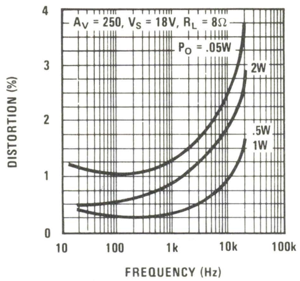
Distortion vs Frequency



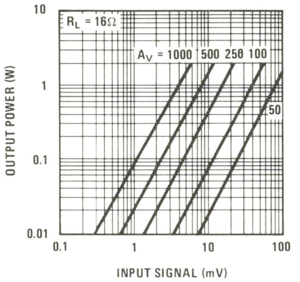
Distortion vs Frequency



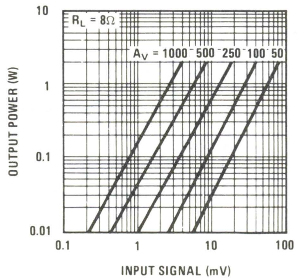
Distortion vs Frequency



Output Power vs Input Signal

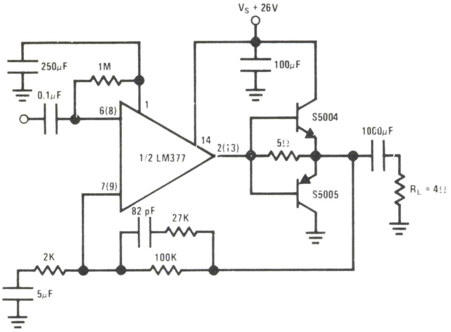


Output Power vs Input Signal

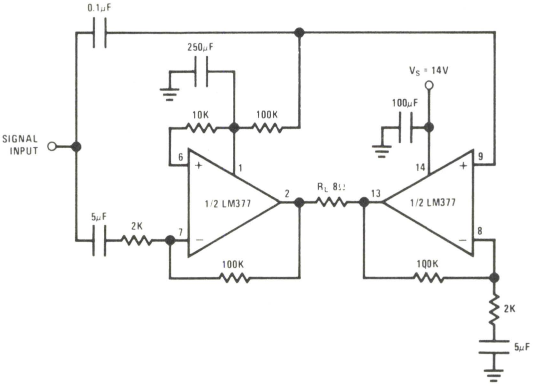


5

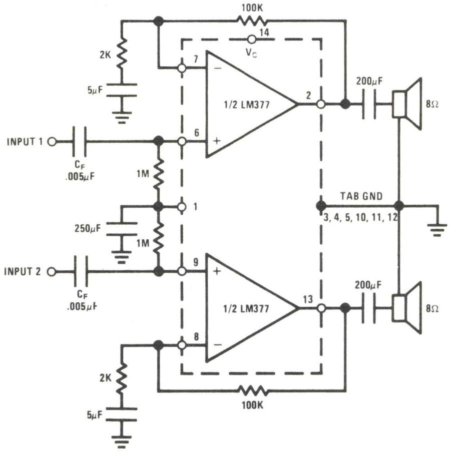
typical applications



15W Per Channel Audio Amplifier



4W Bridge Amplifier



Simple Stereo Amplifier

Consumer Circuits

LM380 audio power amplifier

general description

The LM380 is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self entering to one half the supply voltage.

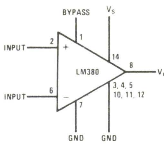
The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout. A mini dual-in-line package version with reduced power capability also available.

Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters,etc.

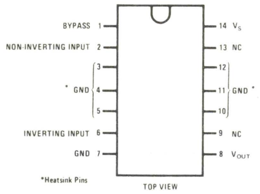
features

- Wide supply voltage range
- Low quiescent power drain
- Voltage gain fixed at 50
- High peak current capability
- Input referenced to GND
- High input impedance
- Low distortion
- Quiescent output voltage is at one-half of the supply voltage
- Standard dual-in-line package

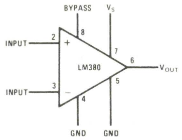
block and connection diagrams



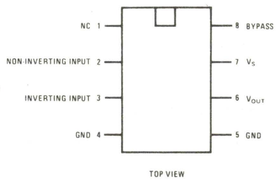
Dual-In-Line Package



Order Number LM380N
See Package 22

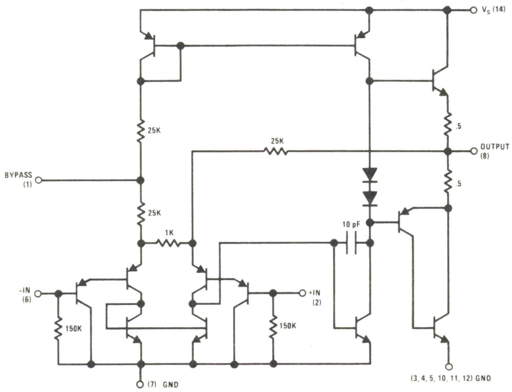


Dual-In-Line Package



Order Number LM380N-8
See Package 20

schematic diagram



5

absolute maximum ratings

Supply Voltage	22V
Peak Current	1.3A
Package Dissipation 14 Pin DIP (Note 6)	5.0W
Package Dissipation 8 Pin DIP (Note 7)	660 mW
Input Voltage	±0.5V
Storage Temperature	−65°C to +150°C
Operating Temperature	0°C to +70°C
Junction Temperature	+150°C
Lead Temperature (Soldering, 10 sec)	+300°C

electrical characteristics (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Power	$P_{OUT(RMS)}$	(Notes 3, 4) $R_L = 8\Omega$, THD = 3%	2.5			W
Gain	A_V		40	50	60	V/V
Output Voltage Swing	V_{OUT}	$R_L = 8\Omega$		14		$V_{p\text{-}p}$
Input Resistance	Z_{IN}			150k		Ω
Total Harmonic Distortion	THD	(Note 4, 5)		0.2		%
Power Supply Rejection Ratio	PSRR	(Note 2)		38		dB
Supply Voltage	V_S		8		22	V
Bandwidth	BW	$P_{OUT} = 2W$, $R_L = 8\Omega$		100k		Hz
Quiescent Supply Current	I_Q			7	25	mA
Quiescent Output Voltage	V_{OUTQ}		8	9.0	10	V
Bias Current	I_{BIAS}	Inputs Floating		100		nA
Short Circuit Current	I_{SC}			1.3		A

Note 1: $V_S = 18V$ and $T_A = 25°C$ unless otherwise specified.

Note 2: Rejection ratio referred to the output with $C_{BYPASS} = 5\ \mu F$.

Note 3: With device Pins 3, 4, 5, 10, 11, 12 soldered into a 1/16" epoxy glass board with 2 ounce copper foil with a minimum surface of 6 square inches.

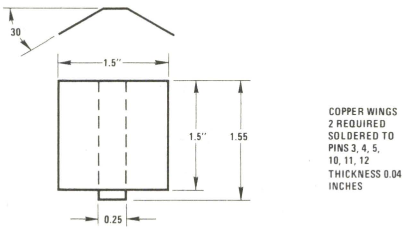
Note 4: If oscillation exists under some load conditions, add 2.7Ω and 0.1 μfd series network from Pin 8 to Gnd.

Note 5: $C_{BYPASS} = 0.47\ \mu fd$ on Pin 1.

Note 6: Pins 3, 4, 5, 10, 11, 12 at 25°C derate 25°C/W above 25°C case.

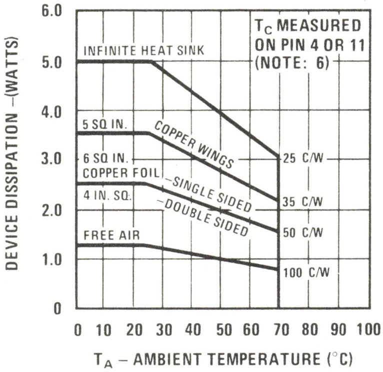
Note 7: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 187°C/W junction to ambient.

heat sink dimensions

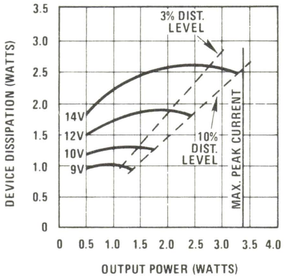


typical performance characteristics

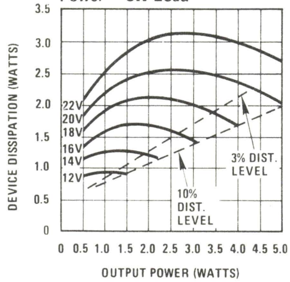
Maximum Device Dissipation vs Ambient Temperature



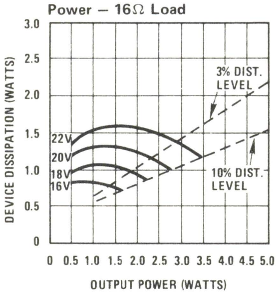
Device Dissipation vs Output Power – 4Ω Load



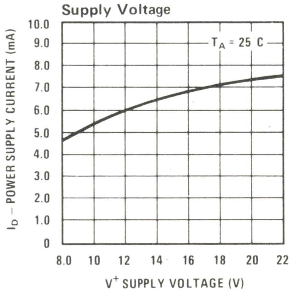
Device Dissipation vs Output Power – 8Ω Load



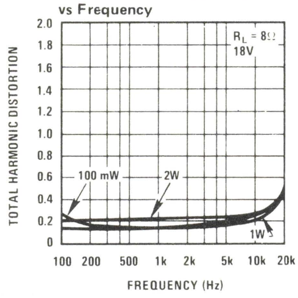
Device Dissipation vs Output Power – 16Ω Load



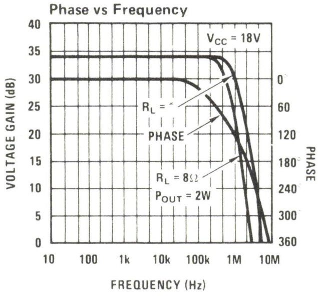
Power Supply Current vs Supply Voltage



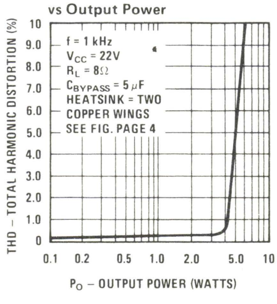
Total Harmonic Distortion vs Frequency



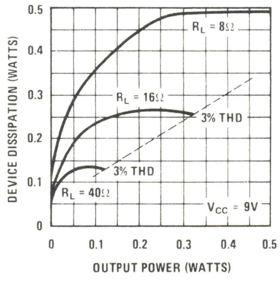
Output Voltage Gain and Phase vs Frequency



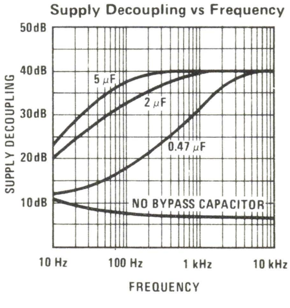
Total Harmonic Distortion vs Output Power



Device Dissipation vs Output Power

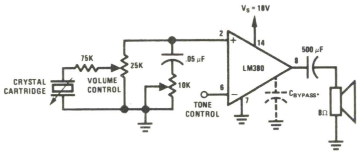


Supply Decoupling vs Frequency

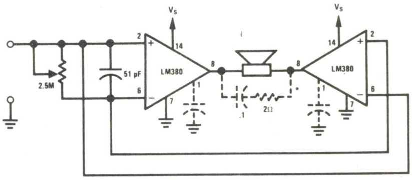


typical applications

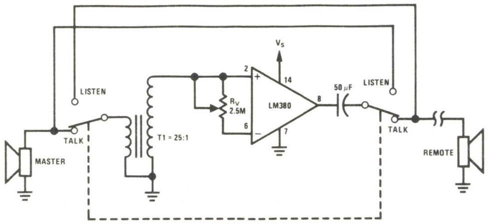
Phono Amplifier



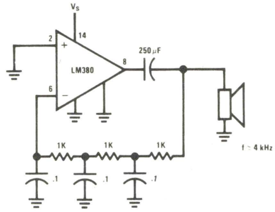
Bridge Amplifier



Intercom



Phase Shift Oscillator



Consumer Circuits

LM381 low noise dual preamplifier

general description

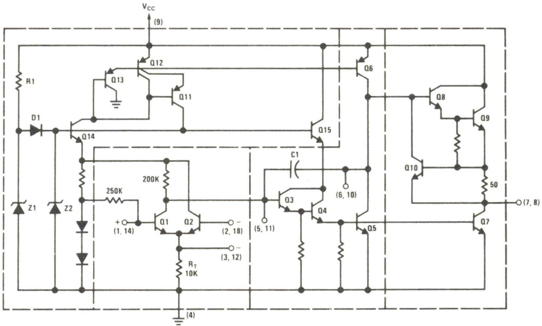
The LM381 is a dual preamplifier for the amplification of low level signals in applications requiring optimum noise performance. Each of the two amplifiers is completely independent, with individual internal power supply decoupler-regulator, providing 120 dB supply rejection and 60 dB channel separation. Other outstanding features include high gain (112 dB), large output voltage swing (V_{CC} −2V) p-p, and wide power bandwidth (75 kHz, $20V_{p\text{-}p}$). The LM381 operates from a single supply across the wide range of 9 to 40V.

Either differential input or single ended input configurations may be selected. The amplifier is internally compensated with the provision for additional external compensation for narrow band applications.

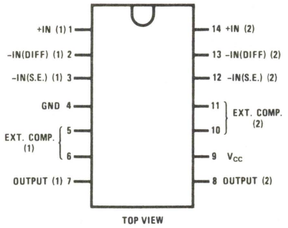
features

- Low Noise — .5 μV total input noise
- High Gain — 112 dB open loop
- Single Supply Operation
- Wide supply range 9–40V
- Power supply rejection 120 dB
- Large output voltage swing $(V_{CC} -2V)_{p\text{-}p}$
- Wide bandwidth 15 MHz unity gain
- Power bandwidth 75 kHz, 20 $V_{p\text{-}p}$
- Internally compensated
- Short circuit protected

schematic and connection diagrams

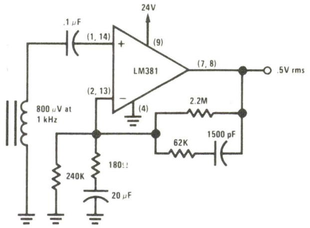


Dual-In-Line Package

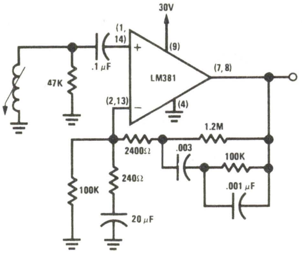


Order Number LM381N
See Package 22

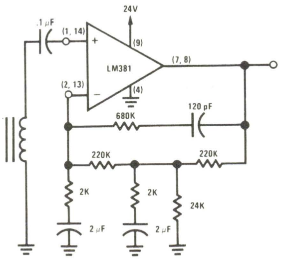
typical applications



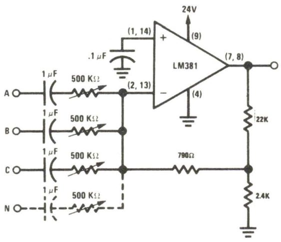
Typical Tape Playback Amplifier



Typical Magnetic Phono Preamp.



Two-Pole Fast Turn-On NAB Tape Preamp



Audio Mixer

absolute maximum ratings

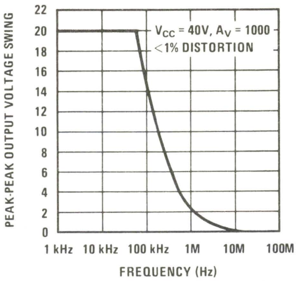
Supply Voltage	+40V
Power Dissipation	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics $T_A = 25°C$, $V_{CC} = 14V$, unless otherwise stated.

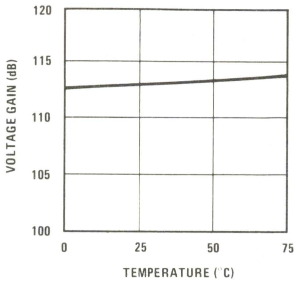
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Voltage Gain	Open Loop (Differential Input)		160,000		V/V
	Open Loop (Single Ended)		320,000		V/V
Supply Current	V_{CC} 9 to 40V, $R_L = \infty$		10		mA
Input Resistance					
(Positive Input)			100		kΩ
(Negative Input)			200		kΩ
Input Current					
(Negative Input)			0.5		μA
Output Resistance	Open Loop		150		Ω
Output Current	Source		8		mA
	Sink		2		mA
Output Voltage Swing	Peak-to-Peak		$V_{CC} - 2$		V
Small Signal Bandwidth			15		MHz
Power Bandwidth	20 $V_{p\text{-}p}$ (V_{CC} = 24V)		75		kHz
Maximum Input Voltage	Linear Operation			300	mVrms
Supply Rejection Ratio	f = 1 kHz		120		dB
Channel Separation	f = 1 kHz		60		dB
Total Harmonic Distortion	75 dB Gain, f = 1 kHz		0.1		%
Total Equivalent Input Noise	R_S = 600Ω, 10 – 10,000 Hz (Single Ended Input)		0.5	0.7	μVrms
LM381A			0.5	0.7	μVrms
LM381			0.5	1.0	μVrms
Noise Figure	50 kΩ, 10 – 10,000 Hz (Single Ended Input)		1.0		dB
	10 kΩ, 10 – 10,000 Hz (Single Ended Input)		1.3		dB
	5 kΩ, 10 – 10,000 Hz (Single Ended Input)		1.6		dB

typical performance characteristics

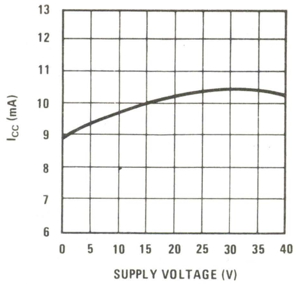
Large Signal Frequency Response



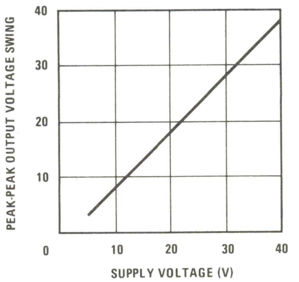
Gain vs Temperature



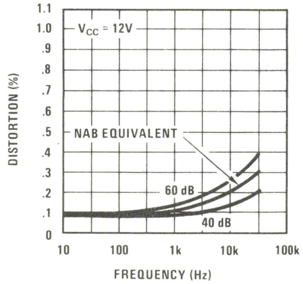
VCC vs ICC



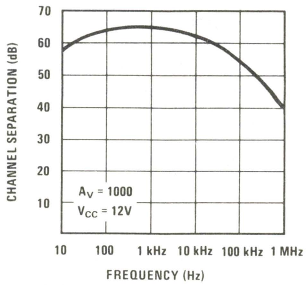
P–P Output Voltage Swing vs VCC



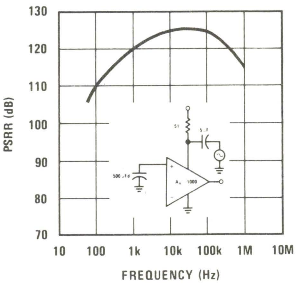
% Distortion



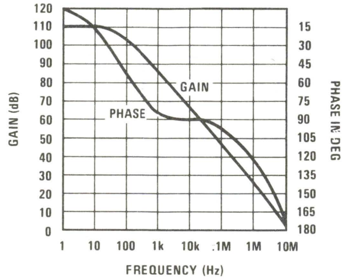
Channel Separation



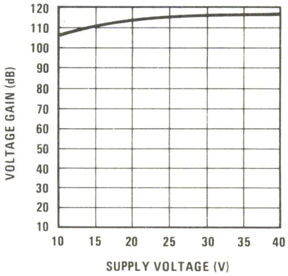
PSRR vs Frequency



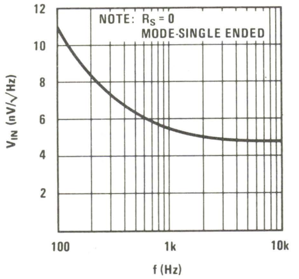
Gain and Phase Response



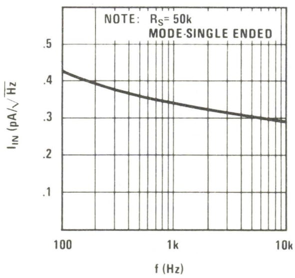
Voltage Gain vs Supply Voltage



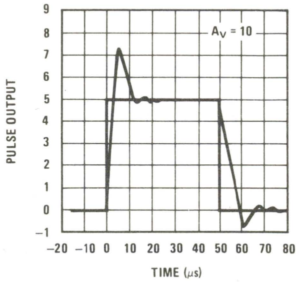
Noise Voltage vs Frequency



Noise Current vs Frequency



Pulse Response



5

Consumer Circuits

LM382 low noise dual preamplifier

general description

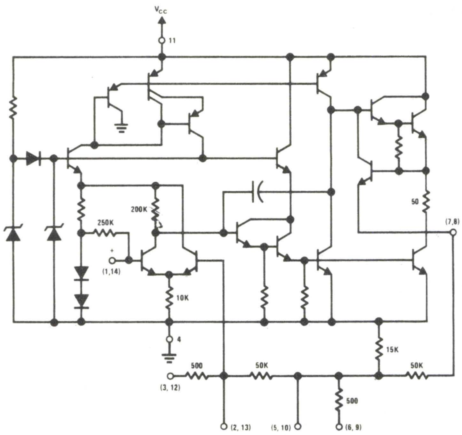
The LM382 is a dual preamplifier for the amplification of low level signals in applications requiring optimum noise performance. Each of the two amplifiers is completely independent, with individual internal power supply decoupler-regulator, providing 120 dB supply rejection and 60 dB channel separation. Other outstanding features include high gain (100 dB), large output voltage swing (V_{CC} −2V) p-p, and wide power bandwidth (75 kHz, 20 $V_{p\text{-}p}$). The LM382 operates from a single supply across the wide range of 9 to 40V.

A resistor matrix is provided on the chip to allow the user to select a variety of closed loop gain options and frequency response characteristics such as flat-band, NAB or RIAA equalization. The circuit is supplied in the 14 lead dual-in-line package.

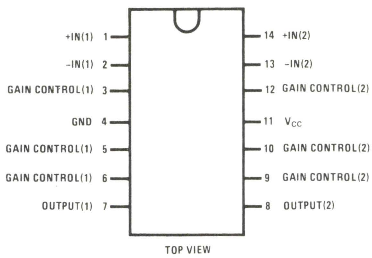
features

- Low noise – 0.8 μV total equivalent input noise
- High gain – 100 dB open loop
- Single supply operation
- Wide supply range 9 to 40V
- Power supply rejection – 120 dB
- Large output voltage swing
- Wide bandwidth – 15 MHz unity gain
- Power bandwidth – 75 kHz, 20 $V_{p\text{-}p}$
- Internally compensated
- Short circuit protected.

schematic and connection diagrams

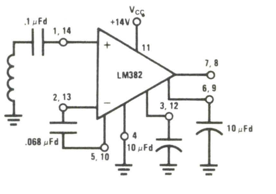


Dual-In-Line Package

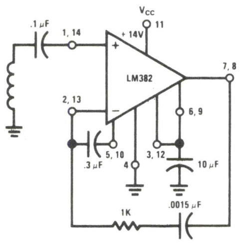


Molded Dual-In-Line Package (N)
Order Number LM382N
See Package 22

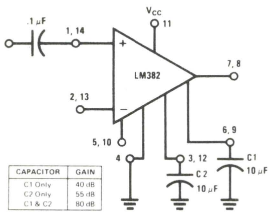
typical applications



Tape Reamplifier (NAB Equilization)



Phono Pre-Amp (RIAA Equilization)



Flat Response – Fixed Gain Configuration

absolute maximum ratings

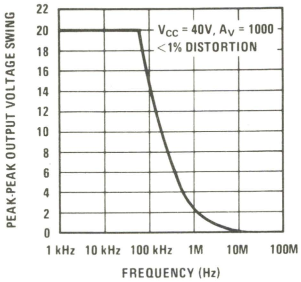
Supply Voltage	+40V
Power Dissipation	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics $T_A = 25°C$, $V_{CC} = 14V$, unless otherwise stated.

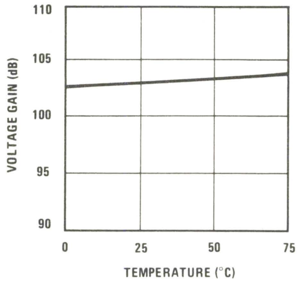
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Voltage Gain	Open Loop (Differential Input)		100,000		V/V
Supply Current	V_{CC} 9 to 40V, $R_L = \infty$		10	16	mA
Input Resistance					
(Positive Input)			100		kΩ
(Negative Input)			200		kΩ
Input Current					
(Negative Input)			0.5		μA
Output Resistance	Open Loop		150		Ω
Output Current	Source		8		mA
	Sink		2		mA
Output Voltage Swing	Peak-to-Peak, R = 10k		$V_{CC} - 2$		V
Small Signal Bandwidth			15		MHz
Power Bandwidth	20 V_{p-p} (V_{CC} = 24V)		75		kHz
Maximum Input Voltage	Linear Operation			300	mVrms
Supply Rejection Ratio	f = 1 kHz		120		dB
Channel Separation	f = 1 kHz	40	60		dB
Total Harmonic Distortion	60 dB Gain, f = 1 kHz		0.1	0.3	%
Total Equivalent Input Noise	R_S = 600Ω, 100 – 10,000 Hz		0.8	1.2	μVrms
Noise Figure	50 kΩ, 100 – 10,000 Hz		1.0		dB
	10 kΩ, 100 – 10,000 Hz		1.6		dB
	5 kΩ, 100 – 10,000 Hz		2.8		dB

typical performance characteristics

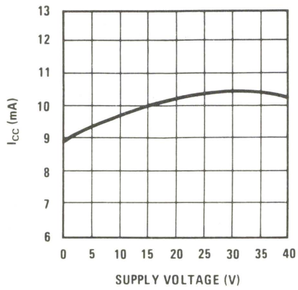
Large Signal Frequency Response



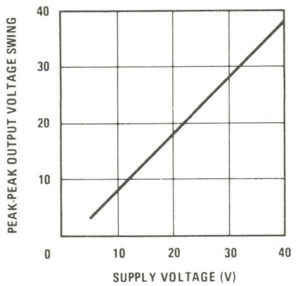
Gain vs Temperature



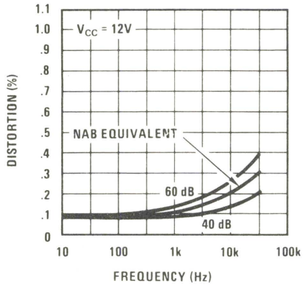
V_{CC} vs I_{CC}



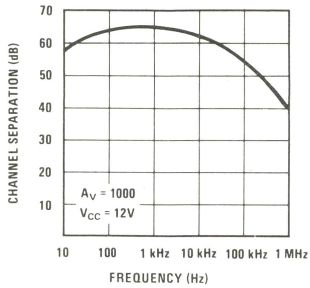
P–P Output Voltage Swing vs V_{CC}



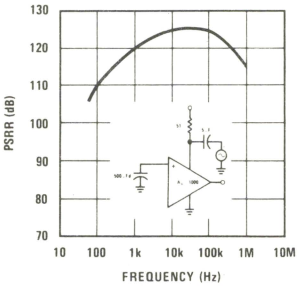
% Distortion



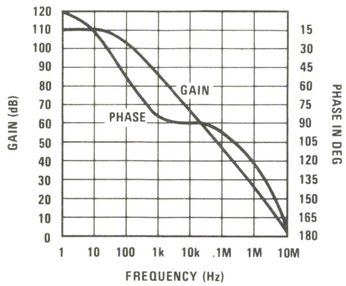
Channel Separation



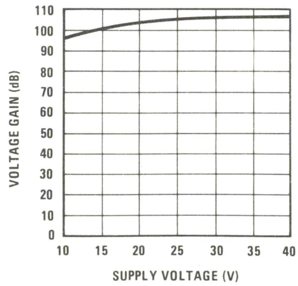
PSRR vs Frequency



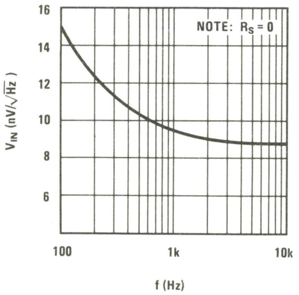
Gain and Phase Response



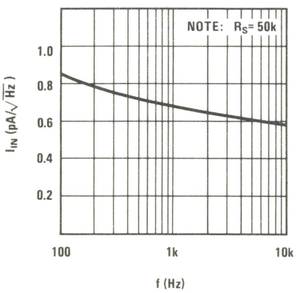
Voltage Gain vs Supply Voltage



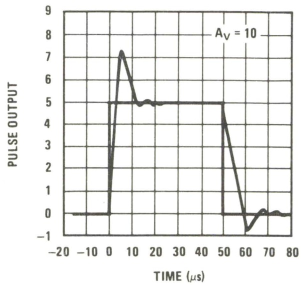
Noise Voltage vs Frequency



Noise Current vs Frequency



Pulse Response



Consumer Circuits

LM565/LM565C phase locked loop

general description

The LM565 and LM565C are general purpose phase locked loops containing a stable, highly linear voltage controlled oscillator for low distortion FM demodulation, and a double balanced phase detector with good carrier suppression. The VCO frequency is set with an external resistor and capacitor, and a tuning range of 10:1 can be obtained with the same capacitor. The characteristics of the closed loop system—bandwidth, response speed, capture and pull in range—may be adjusted over a wide range with an external resistor and capacitor. The loop may be broken between the VCO and the phase detector for insertion of a digital frequency divider to obtain frequency multiplication.

The LM565H is specified for operation over the −55°C to +125°C military temperature range. The LM565CH and LM565CN are specified for operation over the 0°C to +70°C temperature range.

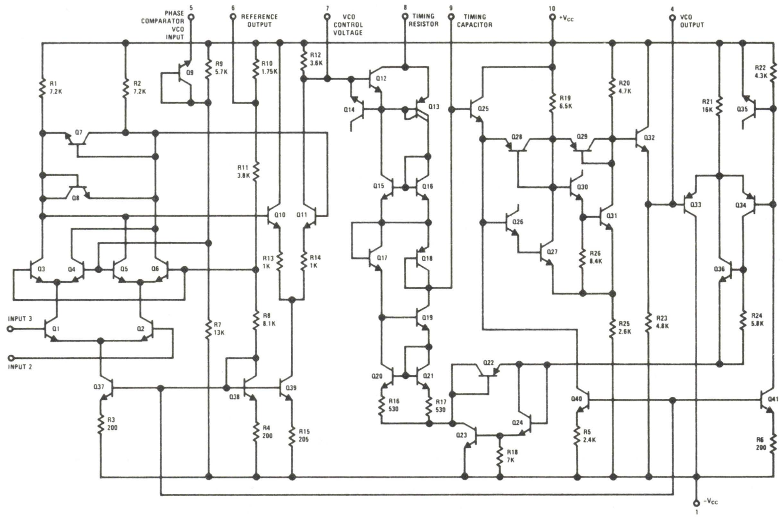
features

- 200 ppm/°C frequency stability of the VCO
- Power supply range of ±5 to ±12 volts with 100 ppm/% typical
- 0.2% linearity of demodulated output
- Linear triangle wave with in phase zero crossings available
- TTL and DTL compatible phase detector input and square wave output
- Adjustable hold in range from ±1% to > ±60%.

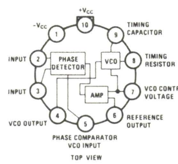
applications

- Data and tape synchronization
- Modems
- FSK demodulation
- FM demodulation
- Frequency synthesizer
- Tone decoding
- Frequency multiplication and division
- SCA demodulators
- Telemetry receivers
- Signal regeneration
- Coherent demodulators.

schematic and connection diagrams

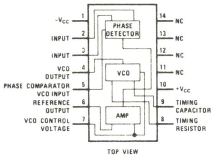


Metal Can Package



Order Number LM565H or LM565CH
See Package 14

Dual-In-Line Package



Order Number LM565CN
See Package 22

absolute maximum ratings

Supply Voltage		±12V
Power Dissipation (Note 1)		300 mW
Differential Input Voltage		±1V
Operating Temperature Range	LM565H	−55°C to +125°C
	LM565CH, LM565CN	0°C to 70°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

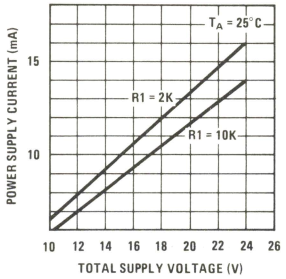
electrical characteristics (AC Test Circuit, T_A = 25°C, V_C = ±6V)

PARAMETER	CONDITIONS	LM565			LM565C/LM565CN			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Power Supply Current			8.0	12.5		8.0	12.5	mA
Input Impedance (Pins 2, 3)	$-4V < V_2 = V_3 < 0V$		5			5		kΩ
VCO Maximum Operating Frequency	C_o = 2.7 pF		500			500		kHz
Operating Frequency Temperature Coefficient			100			200		ppm/°C
Frequency Drift with Supply Voltage			100			200		ppm/%
Triangle Wave Output Voltage		2	2.4		2	2.4		V_{p-p}
Triangle Wave Output Linearity			.2			.5		%
Square Wave Output Level		4.7	5.4		4.7	5.4		V_{p-p}
Output Impedance (Pin 4)			5			5		kΩ
Square Wave Duty Cycle		45	50	55	40	50	60	%
Square Wave Rise Time			20			20		ns
Square Wave Fall Time			50			50		ns
Output Current Sink (Pin 4)			1			1		mA
VCO Sensitivity	f_o = 10 kHz		6600			6600		Hz/V
Demodulated Output Voltage (Pin 7)	±10% Frequency Deviation	250	300		200	300		mV_{pp}
Total Harmonic Distortion	±10% Frequency Deviation		0.2	0.75		0.2	1.5	%
Output Impedance (Pin 7)			3.5			3.5		kΩ
DC Level (Pin 7)			4.5			4.5		V
Output Offset Voltage $\|V_7 - V_6\|$			30	100		50	200	mV
Temperature Drift of $\|V_7 - V_6\|$			500			500		μV/°C
AM Rejection			40			40		dB
Phase Detector Sensitivity K_D			.68			.68		V/radian

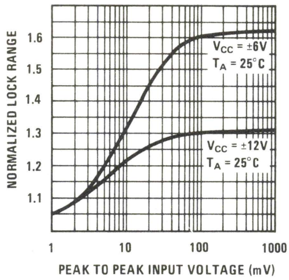
Note 1: The maximum junction temperature of the LM565 is 150°C, while that of the LM565C and LM565CN is 100°C. For operation at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case. Thermal resistance of the dual-in-line package is 100°C/W.

typical performance characteristics

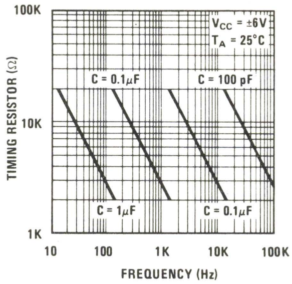
Power Supply Current as a Function of Supply Voltage



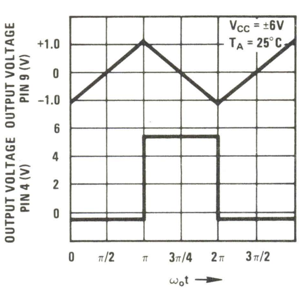
Lock Range as a Function of Input Voltage



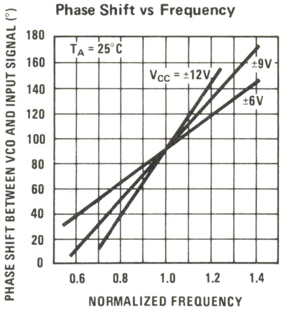
VCO Frequency



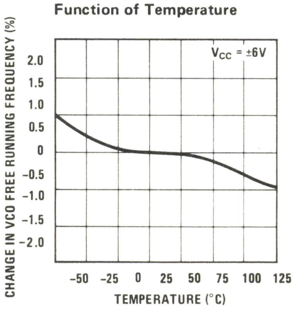
Oscillator Output Waveforms



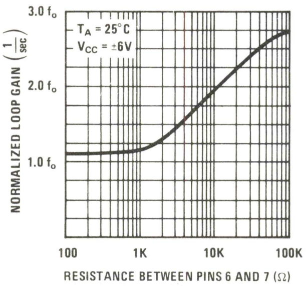
Phase Shift vs Frequency



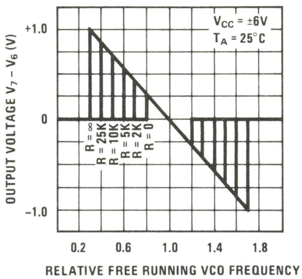
VCO Frequency as a Function of Temperature



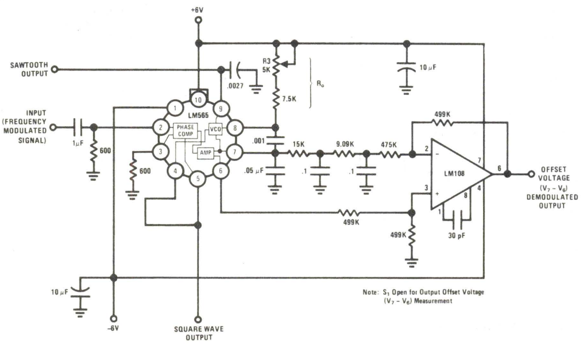
Loop Gain vs Load Resistance



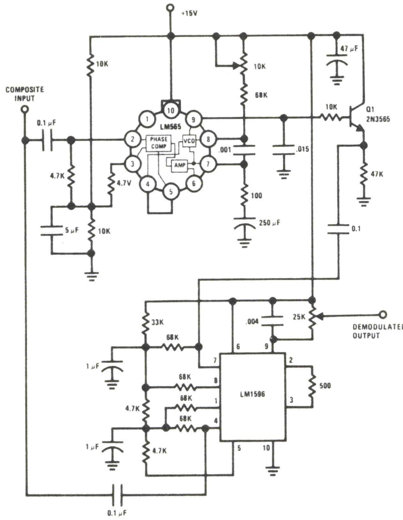
Hold in Range as a Function of R_{6-7}



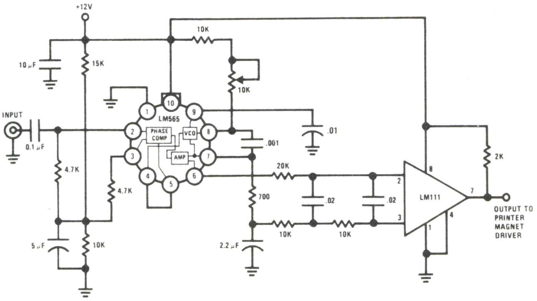
ac test circuit



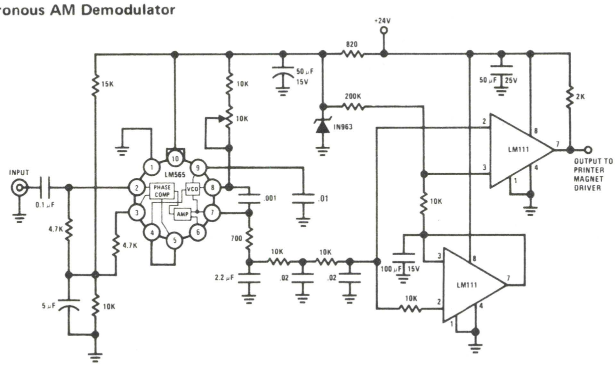
typical applications



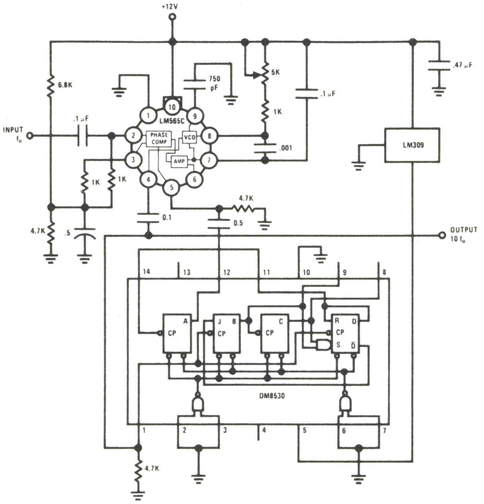
2400 Hz Synchronous AM Demodulator



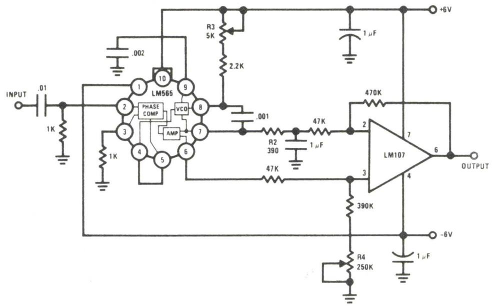
FSK Demodulator (2025-2225 cps)



FSK Demodulator with DC Restoration.



Frequency Multiplier (x10)



IRIG Channel 13 Demodulator

applications information

In designing with phase locked loops such as the LM565, the important parameters of interest are:

FREE RUNNING FREQUENCY

$$f_o \cong \frac{1}{3.7\, R_O C_O}$$

LOOP GAIN: relates the amount of phase change between the input signal and the VCO signal for a shift in input signal frequency (assuming the loop remains in lock). In servo theory, this is called the "velocity error coefficient".

$$\text{Loop gain} = K_o K_D \left(\frac{1}{\text{sec}}\right)$$

$$K_o = \text{oscillator sensitivity} \left(\frac{\text{radians/sec}}{\text{volt}}\right)$$

$$K_D = \text{phase detector sensitivity} \left(\frac{\text{volts}}{\text{radian}}\right)$$

The loop gain of the LM565 is dependent on supply voltage, and may be found from:

$$K_o K_D = \frac{33.6\, f_o}{V_c}$$

f_o = VCO frequency in Hz

V_c = total supply voltage to circuit.

Loop gain may be reduced by connecting a resistor between pins 6 and 7; this reduces the load impedance on the output amplifier and hence the loop gain.

HOLD IN RANGE: the range of frequencies that the loop will remain in lock after initially being locked.

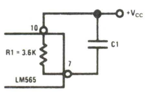
$$f_H = \pm \frac{8\, f_o}{V_c}$$

f_o = free running frequency of VCO

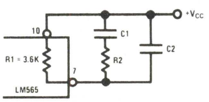
V_c = total supply voltage to the circuit.

THE LOOP FILTER

In almost all applications, it will be desirable to filter the signal at the output of the phase detector (pin 7) this filter may take one of two forms:



Simple Lag Filter



Lag-Lead Filter

A simple lag filter may be used for wide closed loop bandwidth applications such as modulation following where the frequency deviation of the carrier is fairly high (greater than 10%), or where wideband modulating signals must be followed.

The natural bandwidth of the closed loop response may be found from:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_o K_D}{R_1 C_1}}$$

Associated with this is a damping factor:

$$\delta = \frac{1}{2}\sqrt{\frac{1}{R_1 C_1 K_o K_D}}$$

For narrow band applications where a narrow noise bandwidth is desired, such as applications involving tracking a slowly varying carrier, a lead lag filter should be used. In general, if $1/R_1C_1 < K_oK_d$, the damping factor for the loop becomes quite small resulting in large overshoot and possible instability in the transient response of the loop. In this case, the natural frequency of the loop may be found from

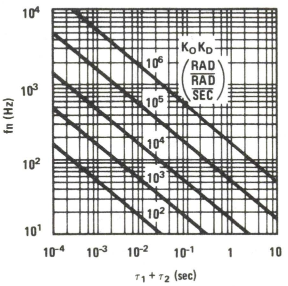
$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_o K_D}{\tau_1 + \tau_2}}$$

$$\tau_1 + \tau_2 = (R_1 + R_2)\, C_1$$

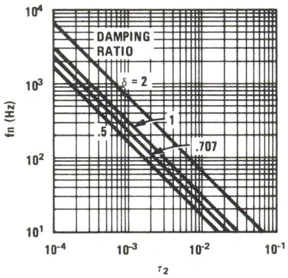
R_2 is selected to produce a desired damping factor δ, usually between 0.5 and 1.0. The damping factor is found from the approximation:

$$\delta \simeq \pi \tau_2 f_n$$

These two equations are plotted for convenience.



Filter Time Constant vs Natural Frequency



Damping Time Constant vs Natural Frequency

Capacitor C_2 should be much smaller than C_1 since its function is to provide filtering of carrier. In general $C_2 \leq 0.1\, C_1$.

Consumer Circuits

LM566/LM566C voltage controlled oscillator

general description

The LM566/LM566C are general purpose voltage controlled oscillators which may be used to generate square and triangular waves, the frequency of which is a very linear function of a control voltage. The frequency is also a function of an external resistor and capacitor.

The LM566 is specified for operation over the −55°C to +125°C military temperature range. The LM566C is specified for operation over the 0°C to +70°C temperature range.

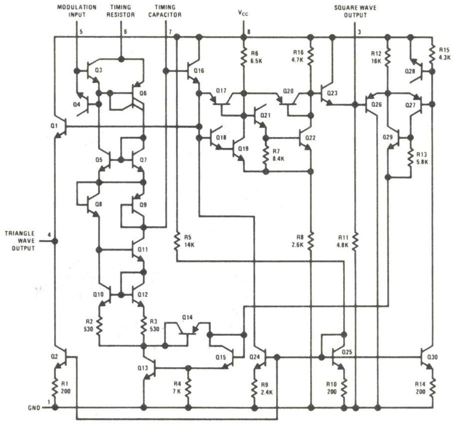
features

- Wide supply voltage range: 10 to 24 volts
- Very linear modulation characteristics
- High temperature stability
- Excellent supply voltage rejection
- 10 to 1 frequency range with fixed capacitor
- Frequency programmable by means of current, voltage, resistor or capacitor.

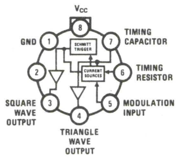
applications

- FM modulation
- Signal generation
- Function generation
- Frequency shift keying
- Tone generation

schematic and connection diagrams



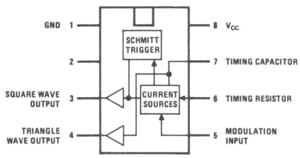
Metal Can



TOP VIEW

Order Number LM566H or LM566CH
See Package 11

Dual-In-Line Package

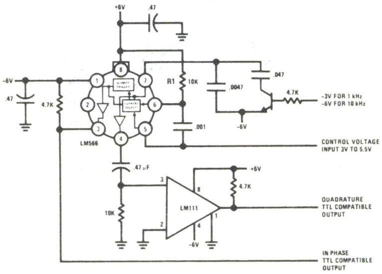


TOP VIEW

Order Number LM566CN
See Package 20

typical application

1 kHz and 10 kHz TTL Compatible Voltage Controlled Oscillator



applications information

The LM566 may be operated from either a single supply as shown in this test circuit, or from a split (±) power supply. When operating from a split supply, the square wave output (pin 4) is TTL compatible (2 mA current sink) with the addition of a 4.7 kΩ resistor from pin 3 to ground.

A .001 μF capacitor is connected between pins 5 and 6 to prevent parasitic oscillations that may occur during VCO switching.

$$f_O = \frac{2(V^+ - V_5)}{R_1 C_1 V^+}$$

where

$2K < R_1 < 20K$

and V_5 is voltage between pin 5 and ground.

absolute maximum ratings

Power Supply Voltage		26V
Power Dissipation (Note 1)		300 mW
Operating Temperature Range	LM566	−55°C to +125°C
	LM566C	0°C to 70°C
Lead Temperature (Soldering, 10 sec)		300°C

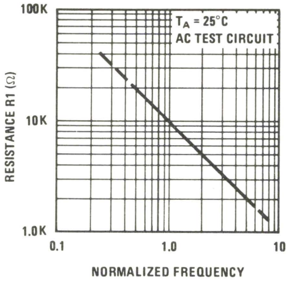
electrical characteristics V_{CC} = 12V, T_A = 25°C, AC Test Circuit

PARAMETER	CONDITIONS	LM566			LM566C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Maximum Operating Frequency	R_0 = 2k, C_0 = 2.7 pF		1			1		MHz
Input Voltage Range Pin 5		3/4 V_{CC}		V_{CC}	3/4 V_{CC}		V_{CC}	
Average Temperature Coefficient of Operating Frequency			100			200		ppm/°C
Supply Voltage Rejection			1			2		%/V
Input Impedance Pin 5			1			1		MΩ
VCO Sensitivity	f_0 = 10 kHz		6600			6600		Hz/V
FM Distortion	±10% Deviation		.2	.75		.2	1.5	%
Maximum Sweep Rate			1			1		MHz
Sweep Range			10:1			10:1		
Output Impedance Pin 3			50			50		Ω
Pin 4			50			50		Ω
Square Wave Output Level	R_{L1} = 10k	5.0	5.4		5.0	5.4		V p-p
Triangle Wave Output Level	R_{L2} = 10k	2.0	2.4					V p-p
Square Wave Duty Cycle		45		55	40		60	%
Square Wave Rise Time			20			20		ns
Square Wave Fall Time			50			50		ns
Triangle Wave Linearity			.2			.5		%

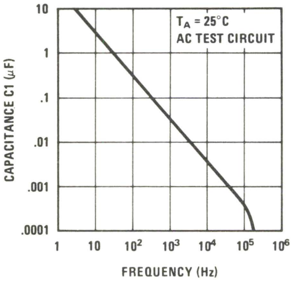
Note 1: The maximum junction temperature of the LM566 is 150°C, while that of the LM566C is 100°C. For operating at elevated junction temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W. The thermal resistance of the dual-in-line package is 100°C/W.

typical performance characteristics

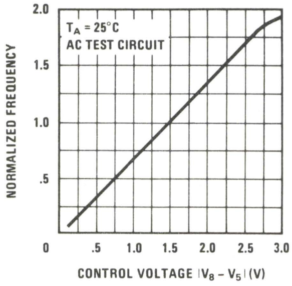
Operating Frequency as a Function of Timing Resistor



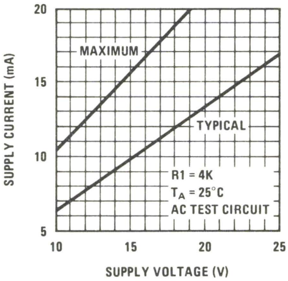
Operating Frequency as a Function of Timing Capacitor



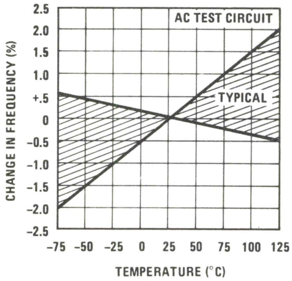
Normalized Frequency as a Function of Control Voltage



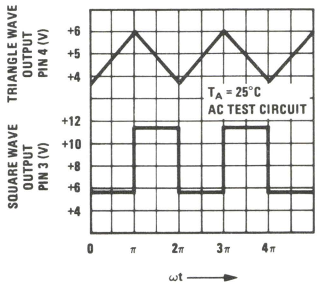
Power Supply Current



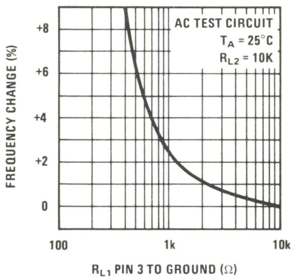
Temperature Stability



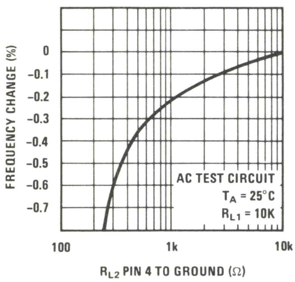
VCO Waveforms



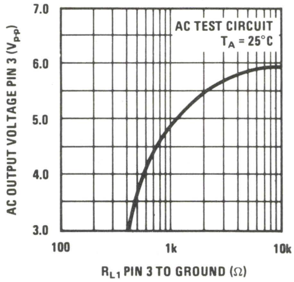
Frequency Stability vs Load Resistance (Square Wave Output)



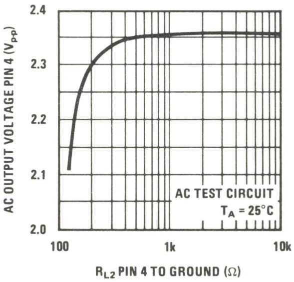
Frequency Stability vs Load Impedance (Triangle Output)



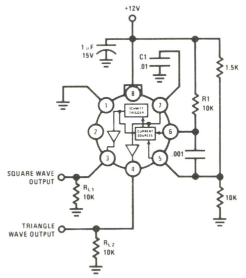
Square Wave Output Characteristics



Triangle Wave Output Characteristics



ac test circuit



LM567/LM567C tone decoder

general description

The LM567 and LM567C are general purpose tone decoders designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The circuit consists of an I and Q detector driven by a voltage controlled oscillator which determines the center frequency of the decoder. External components are used to independently set center frequency, bandwidth and output delay.

features

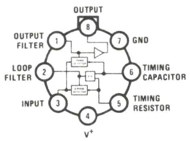
- 20 to 1 frequency range with an external resistor
- Logic compatible output with 100 mA current sinking capability
- Bandwidth adjustable from 0 to 14%
- High rejection of out of band signals and noise
- Immunity to false signals
- Highly stable center frequency
- Center frequency adjustable from 0.01 Hz to 500 kHz

applications

- Touch tone decoding
- Precision oscillator
- Frequency monitoring and control
- Wide band FSK demodulation
- Ultrasonic controls
- Carrier current remote controls
- Communications paging decoders

schematic and connection diagrams

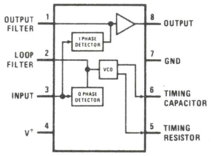
Metal Can Package



TOP VIEW

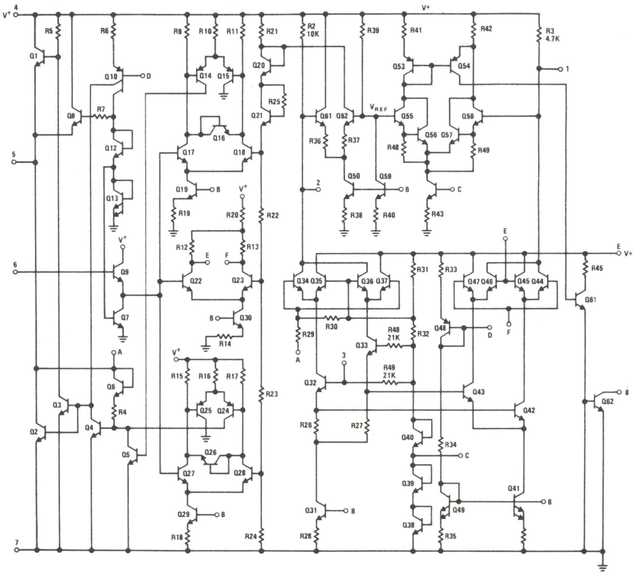
Order Number LM567H or LM567CH
See Package 11

Dual-In-Line Package



TOP VIEW

Order Number LM567CN
See Package 20



absolute maximum ratings

Supply Voltage Pin	10V
Power Dissipation (Note 1)	300 mW
V_8	15V
V_3	–10V
V_3	V_8 + 0.5V
Storage Temperature Range	–65°C to +150°C

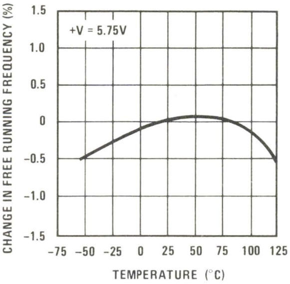
electrical characteristics (AC Test Circuit, T_A = 25°C, V_C = 5V)

PARAMETERS	CONDITIONS	LM567			LM567C/LM567CN			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Power Supply Voltage Range		4.75		9.0	4.75		9.0	V
Power Supply Current	R_L = 20k							
Quiescent			6	8		7	10	mA
Power Supply Current	R_L = 20k							
Activated			11	13		12	15	mA
Input Resistance			20			20		kΩ
Smallest Detectable Input Voltage	I_L = 100 mA, $f_i = f_o$		20	25		20	25	mVrms
Largest No Output Input Voltage	I_C = 100 mA, $f_i = f_o$	10	15		10	15		mVrms
Largest Simultaneous Outband Signal to Inband Signal Ratio			6			6		dB
Minimum Input Signal to Wideband Noise Ratio	B_n = 140 kHz		–6			–6		dB
Largest Detection Bandwidth		12	14	16	10	14	18	% of f_o
Largest Detection Bandwidth Skew			1	2		2	3	% of f_o
Largest Detection Bandwidth Variation with Temperature			±0.1			±0.1		%/°C
Largest Detection Bandwidth Variation with Supply Voltage			±2			±2		%V
Highest Center Frequency		100	500		100	500		kHz
Center Frequency Stability	$0 < T_A < 70$		35 ± 60			35 ± 60		ppm/°C
	$-55 < T_A < +125$		35 ± 140					ppm/°C
Center Frequency Shift with Supply Voltage			0.5	1.0		2	7	%/V
Fastest ON-OFF Cycling Rate			$f_o/20$			$f_o/20$		
Output Leakage Current	V_8 = 15V		0.01	25		0.01	25	µA
Output Saturation Voltage	e_i = 25 mV, I_8 = 30 mA		0.2	0.4		0.2	0.4	V
	e_i = 25 mV, I_8 = 100 mA		0.6	1.0		0.6	1.0	
Output Fall Time (Note 3)			30			30		ns
Output Rise Time (Note 3)			150			150		ns

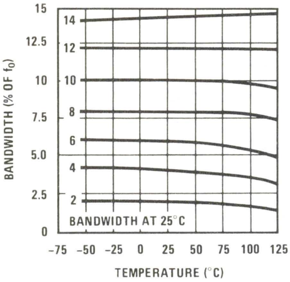
Note 1: The maximum junction temperature of the LM567 is 150°C, while that of the LM567C and LM567CN is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient or 45°C/W, junction to case. For the DIP the device must be derated based on a thermal resistance of 187°C/W, junction to ambient.

typical performance characteristics

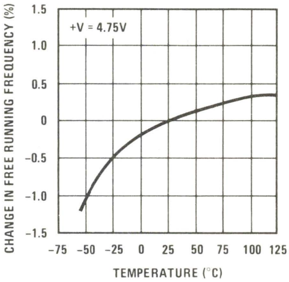
Typical Frequency Drift with Temperature (Mean and S.D.)



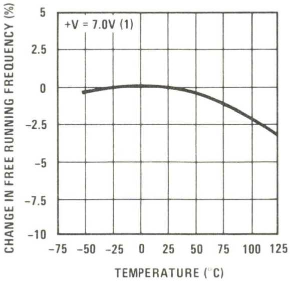
Typical Bandwidth Variation with Temperature



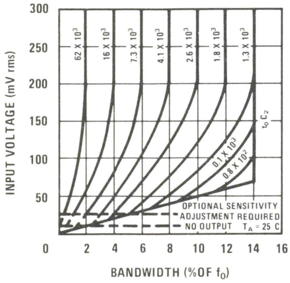
Typical Frequency Drift with (Mean and S.D.) Temperature



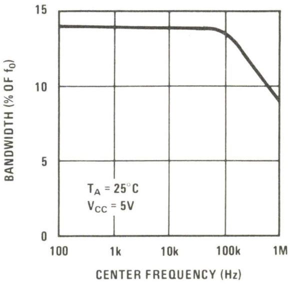
Typical Frequency Drift with Temperature (Mean and S.D.)



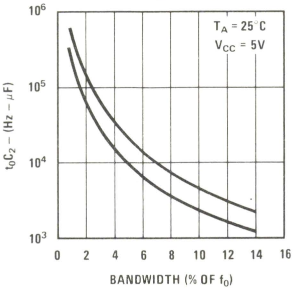
Bandwith vs Input Signal Amplitude



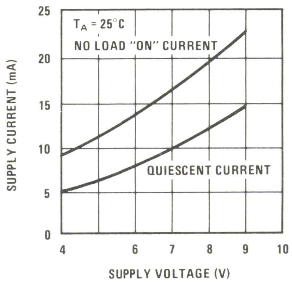
Largest Detection Bandwidth



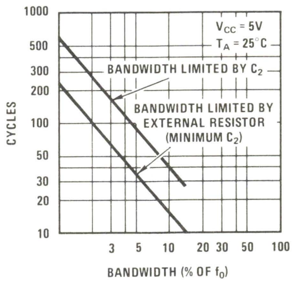
Detection Bandwidth as a Function of C_2 and C_3



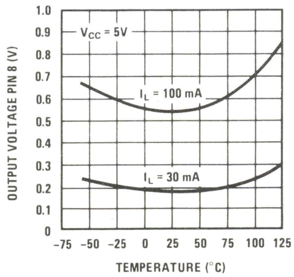
Typical Supply Current vs Supply Voltage



Greatest Number of Cycles Before Output



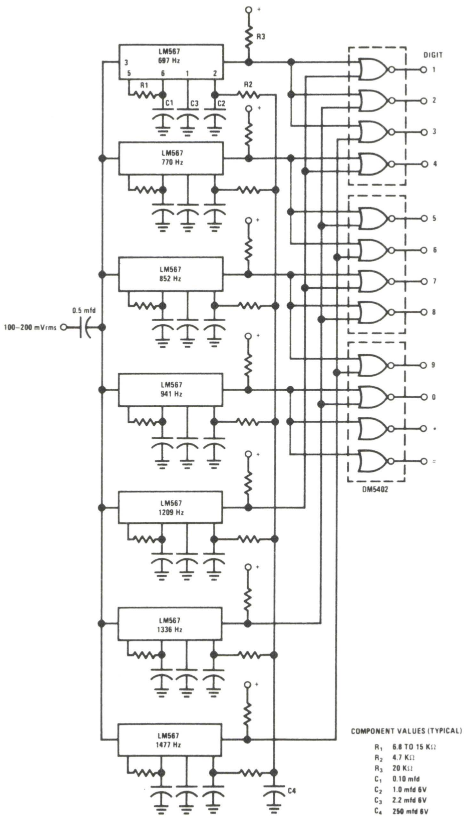
Typical Output Voltage vs Temperature



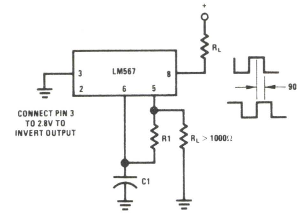
5

typical applications

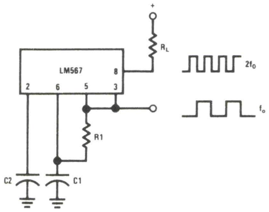
Touch-Tone Decoder



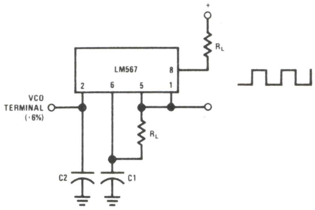
Oscillator with Quadrature Output



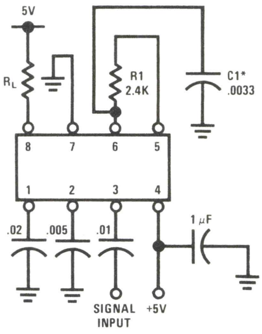
Oscillator with Double Frequency Output



Precision Oscillator Drive 100 mA Loads



ac test circuit



f_i = 100 kHz +5V

*Note: Adjust for f_o = 100 kHz

applications information

The center frequency of the tone decoder is equal to the free running frequency of the VCO. This is given by

$$f_o \cong \frac{1}{R_1 C_1}$$

The bandwidth of the filter may be found from the approximation

$$BW = 1070 \sqrt{\frac{V_i}{f_o C_2}}$$

Where:

V_i = Input voltage (volts rms)

C_2 = Capacitance at Pin 2 (μF)

Consumer Circuits

LM703L low power drain rf/if amplifier

general description

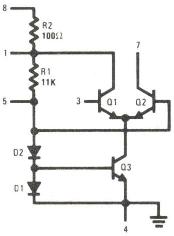
The LM703L is a monolithic RF-IF amplifier, having an efficient DC biasing system, reducing demands upon power supply and decoupling elements. Its low internal feedback guarantees a high stability-limited gain.

Applications include limiting and nonlimiting amplifiers, mixers, and RF oscillators. The LM703L is specifically characterized for operation in consumer applications such as TV sound IF, FM-IF limiter amplifier, and Chroma reference oscillator for color TV.

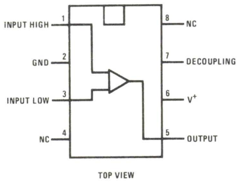
features

- Power Consumption 96 mW (max.)
- Forward Transadmittance 33 mmhos
- Input Conductance 0.35 mmhos
- Output Conductance 0.03 mmhos
- Peak-to-Peak Output Current 5.0 mA

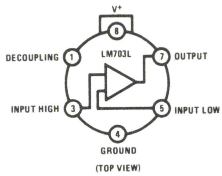
schematic and connection diagrams



Pin connections are for H package.



Order Number LM703LN
See Package 20.

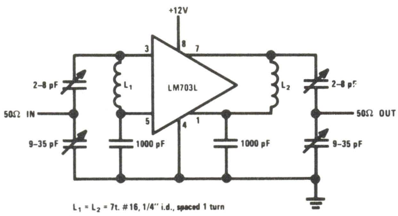


NOTE: Pin 4 connected to case.

Order Number LM703LH
See Package 10

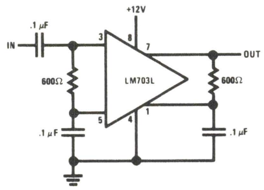
typical applications

100 MHz Narrow Band Amplifier

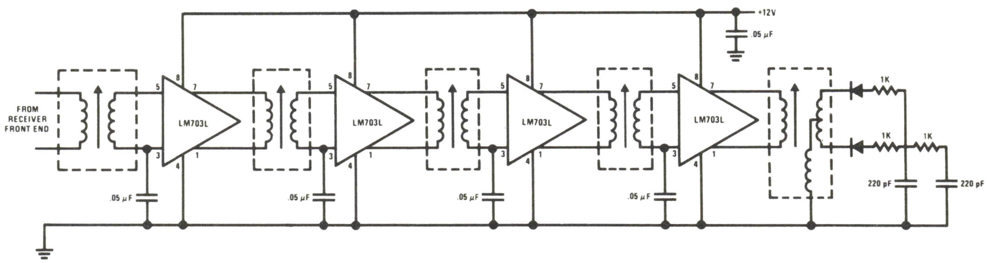


$L_1 = L_2$ = 7t. #16, 1/4" i.d., spaced 1 turn

RC Coupled Video Amplifier



Four Stage 10.7 MHz FM-IF Amplifier



5

absolute maximum ratings

Supply Voltage	20V
Output Collector Voltage	24V
Voltage Between Input Terminals	±5.0V
Internal Power Dissipation	200 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

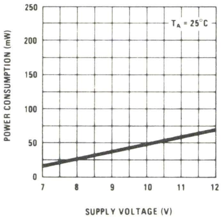
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Power Consumption	$e_{in} = 0$		71	96	mW
Quiescent Output Current	$e_{in} = 0$	1.5	2.5	3.3	mA
Peak-to-Peak Output Current	$e_{in} = 400$ mV rms, f = 10.7 MHz	3.0	5.0		mA
Output Saturation Voltage				1.7	V
Forward Transadmittance	$e_{in} = 10$ mV rms, $f \leq 10.7$ MHz	24.0	33.0		mmho
Reverse Transadmittance	$e_{in} = 10$ mV rms, $f \leq 10.7$ MHz		0.002		mmho
Input Conductance	$e_{in} = < 10$ mV rms, $f \leq 10.7$ MHz		0.35	1.0	mmho
Input Capacitance	$e_{in} < 10$ mV rms, $f \leq 10.7$ MHz		9.0	12.5	pF
Output Capacitance	$f \leq 10.7$ MHz		2.6	4.0	pF
Output Conductance	$f \leq 10.7$ MHz		0.03	0.05	mmho
Noise Figure	$R_S = 500\Omega$, f = 10.7 MHz $R_S = 500\Omega$, f = 100 MHz		6.0 8.0		dB dB
Maximum Stable Gain	f = 100 MHz		28.0		dB

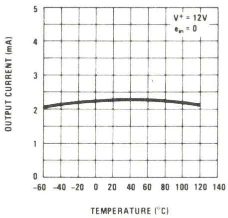
Note 1: These specifications apply for $T_A = 25°C$, $V^+ = 12V$ unless otherwise specified.

typical performance characteristics

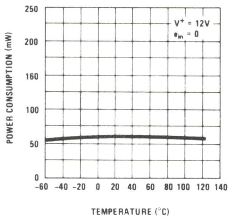
Power Consumption as a Function of Supply Voltage



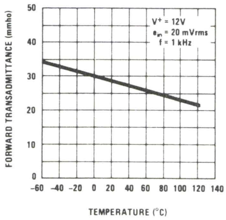
Output Current as a Function of Ambient Temperature



Power Consumption as a Function of Ambient Temperature



Forward Transadmittance as a Function of Ambient Temperature



Note: For additional performance curves, and packaging, see LM703/C/E data sheet.

Consumer Circuits

LM733/LM733C differential video amp

general description

The LM733/LM733C is a two-stage, differential input, differential output, wide-band video amplifier. The use of internal series-shunt feedback gives wide bandwidth with low phase distortion and high gain stability. Emitter-follower outputs provide a high current drive, low impedance capability. It's 120 MHz bandwidth and selectable gains of 10, 100, and 400, without need for frequency compensation, make it a very useful circuit for memory element drivers, pulse amplifiers, and wide band linear gain stages.

The LM733 is specified for operation over the −55°C to +125°C military temperature range. The LM733C is specified for operation over the 0°C to +70°C temperature range.

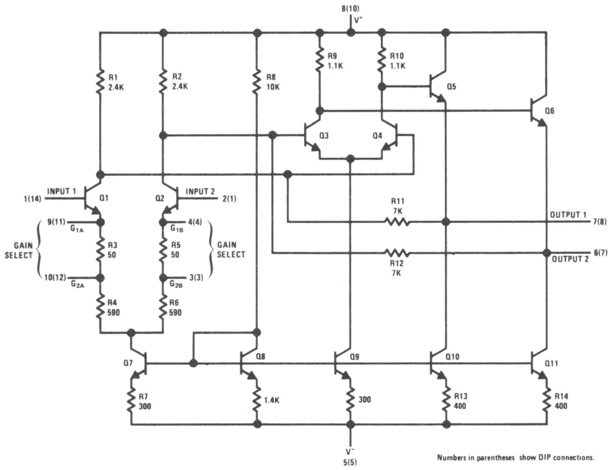
features

- 120 MHz bandwidth
- 250 kΩ input resistance
- Selectable gains of 10, 100, 400
- No frequency compensation
- High common mode rejection ratio at high frequencies.

applications

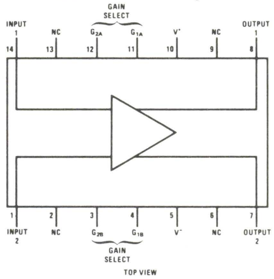
- Magnetic tape systems
- Disk file memories
- Thin and thick film memories
- Woven and plated wire memories
- Wide band video amplifiers.

schematic and connection diagrams



Numbers in parentheses show DIP connections.

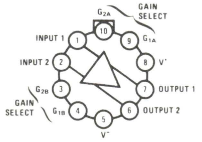
Dual-In-Line Package



Order Number LM733D or LM733CD
See Package 1

Order Number LM733CN
See Package 22

Metal Can Package

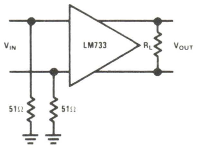


NOTE: Pin 5 connected to case.
TOP VIEW

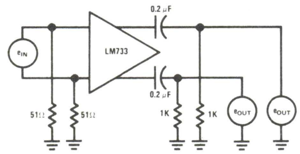
Order Number LM733H or LM733CH
See Package 14

test circuits

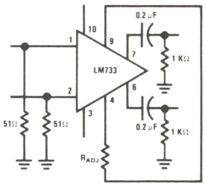
Test Circuit 1



Test Circuit 2



Voltage Gain Adjust Circuit



$V_S = \pm 6V$
$T_A = 25°C$
(Pin numbers apply to TO-5 package.)

absolute maximum ratings

Differential Input Voltage	±5V
Common Mode Input Voltage	±6V
V_{CC}	±8V
Output Current	10 mA
Power Dissipation (Note 1)	500 mW
Junction Temperature	+150°C
Storage Temperature Range	–65°C to +150°C
Operating Temperature Range LM733	–55°C to +125°C
LM733C	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, unless otherwise specified, see test circuits, V_S = ±6.0V)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1 (Note 2)			300	400	500	250	400	600	
Gain 2 (Note 3)	1	R_L = 2 kΩ V_{OUT} = 3 $V_{p\text{-}p}$	90	100	110	80	100	120	
Gain 3 (Note 4)			9.0	10	11	8.0	10	12	
Bandwidth									
Gain 1				40			40		MHz
Gain 2	2			90			90		MHz
Gain 3				120			120		MHz
Rise Time									
Gain 1		V_{OUT} = 1 $V_{p\text{-}p}$		10.5			10.5		ns
Gain 2	2			4.5	10		4.5	12	ns
Gain 3				2.5			2.5		ns
Propagation Delay		V_{OUT} = 1 $V_{p\text{-}p}$							
Gain 1				7.5			7.5		ns
Gain 2	2			6.0	10		6.0	10	ns
Gain 3				3.6			3.6		ns
Input Resistance									
Gain 1				4.0			4.0		kΩ
Gain 2			20	30		10	30		kΩ
Gain 3				250			250		kΩ
Input Capacitance		Gain 2		2.0			2.0		pF
Input Offset Current				0.4	3.0		0.4	5.0	μA
Input Bias Current				9.0	20		9.0	30	μA
Input Noise Voltage		BW = 1 kHz to 10 MHz		12			12		μVrms
Input Voltage Range	1		±1.0			±1.0			V
Common Mode Rejection Ratio									
Gain 2	1	V_{CM} = ±1V f ≤ 100 kHz	60	86		60	86		dB
Gain 2		V_{CM} = ±1V f = 5 MHz		60			60		dB
Supply Voltage Rejection Ratio									
Gain 2	1	ΔV_S = ±0.5V	50	70		50	70		dB
Output Offset Voltage									
Gain 1	1	R_L = ∞		0.6	1.5		0.6	1.5	V
Gain 2 and 3				0.35	1.0		0.35	1.5	V
Output Common Mode Voltage	1	R_L = ∞	2.4	2.9	3.4	2.4	2.9	3.4	V
Output Voltage Swing	1	R_L = 2k	3.0	4.0		3.0	4.0		
Output Sink Current			2.5	3.6		2.5	3.6		mA
Output Resistance				20			20		Ω
Power Supply Current	1	R_L = ∞		18	24		18	24	mA

electrical characteristics

(The following specifications apply for $-55°C < T_A < 125°C$ for the LM733 and $0°C < T_A < 70°C$ for the LM733C, $V_S = \pm 6.0V$)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1			200		600	250		600	
Gain 2	1	$R_L = 2\ k\Omega$, $V_{OUT} = 3\ V_{p\text{-}p}$	80		120	80		120	
Gain 3			8.0		12.0	8.0		12.0	
Input Resistance Gain 2			8			8			kΩ
Input Offset Current					5			6	μA
Input Bias Current					40			40	μA
Input Voltage Range	1		±1			±1			V
Common Mode Rejection Ratio									
Gain 2	1	$V_{CM} = \pm 1V$, $f \leq 100\ kHz$	50			50			dB
Supply Voltage Rejection Ratio									
Gain 2	1	$\Delta V_S = \pm 0.5V$	50			50			dB
Output Offset Voltage									
Gain 1	1	$R_L = \infty$			1.5			1.5	V
Gain 2 and 3					1.2			1.5	V
Output Voltage Swing	1	$R_L = 2k$	2.5			2.8			V_{PP}
Output Sink Current			2.2			2.5			mA
Power Supply Current	1	$R_L = \infty$			27			27	mA

Note 1: The maximum junction temperature of the LM733 is 150°C, while that of the LM733C is 100°C. For operation at elevated temperatures, devices in the TO-100 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case. Thermal resistance of the dual-in-line package is 100°C/W.

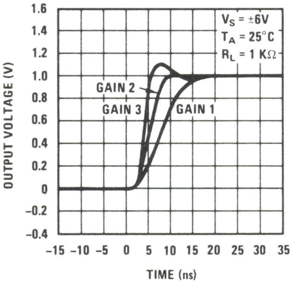
Note 2: Pins G1A and G1B connected together.

Note 3: Pins G2A and G2B connected together.

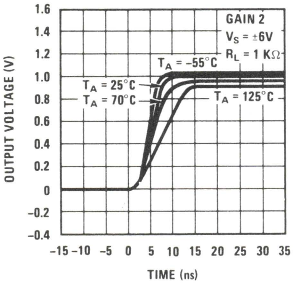
Note 4: Gain select pins open.

typical performance characteristics

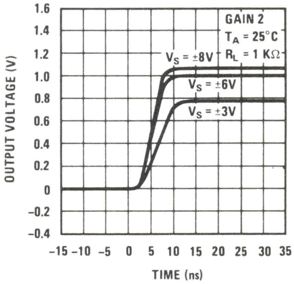
Pulse Response



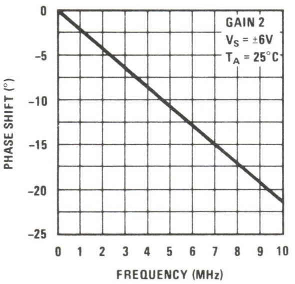
Pulse Response vs Temperature



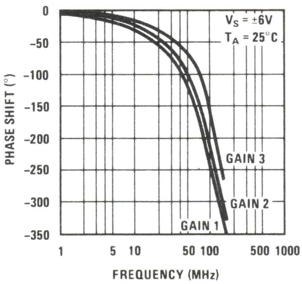
Pulse Response vs Supply Voltage



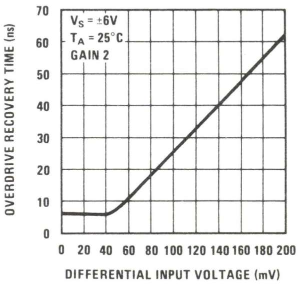
Phase Shift vs Frequency



Phase Shift vs Frequency



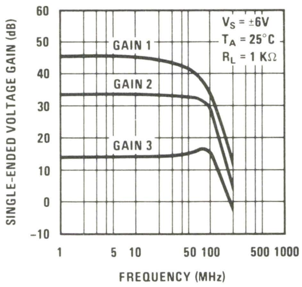
Differential Overdrive Recovery Time



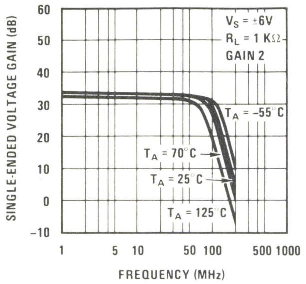
5

typical performance characteristics (con't)

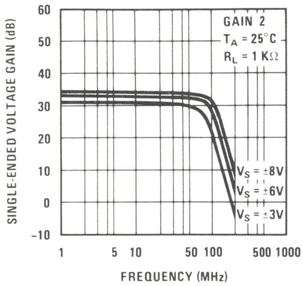
Voltage Gain vs Frequency



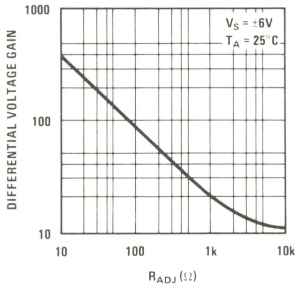
Gain vs Frequency Temperature



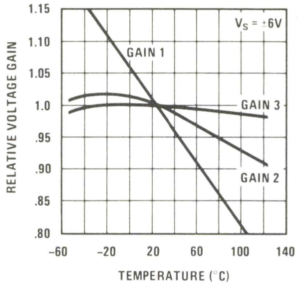
Gain vs Frequency vs Supply Voltage



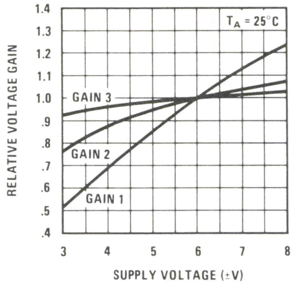
Voltage Gain vs R_{ADJ}



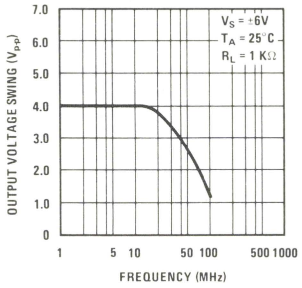
Voltage Gain vs Temperature



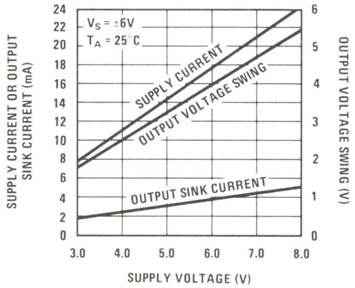
Voltage Gain vs Supply Voltage



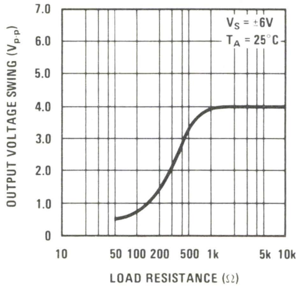
Output Voltage Swing vs Frequency



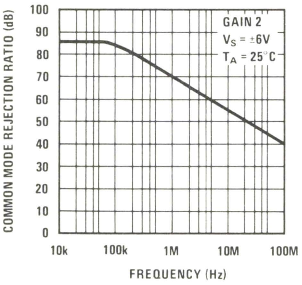
Supply Current, Output Voltage and Current Swing vs Supply Voltage



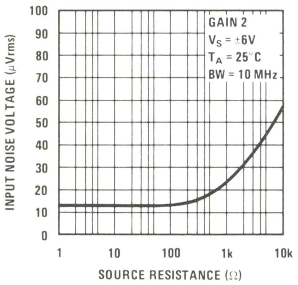
Output Voltage Swing vs Load Resistance



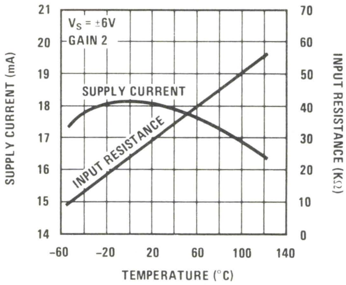
Common Mode Rejection Ratio vs Frequency



Input Noise Voltage vs Source Resistance



Supply Current and Input Resistance vs Temperature



Consumer Circuits

LM746 color television chroma demodulator

general description

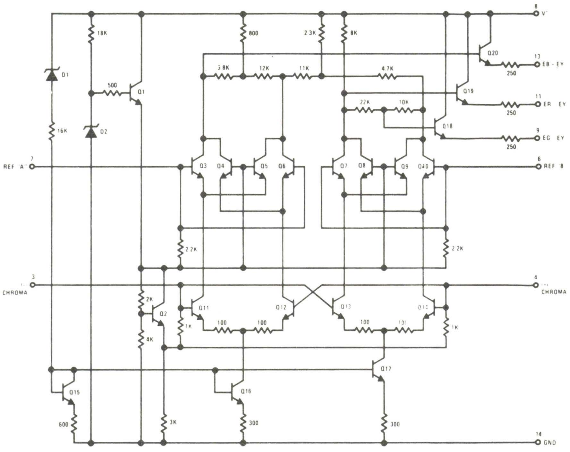
The LM746 is a monolithic silicon integrated circuit which demodulates the chroma subcarrier information contained in a color television video signal and provides color-difference signals at the outputs

The low DC voltage drift of the outputs insures excellent performance in direct-coupled chrominance output circuitry.

features

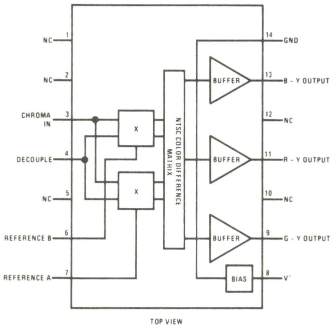
- Low output voltage drift with temperature
- Doubly balanced demodulation
- Internal color-difference matrix for NTSC color television
- 10V peak-to-peak $E_B - E_Y$ output

schematic and block diagrams



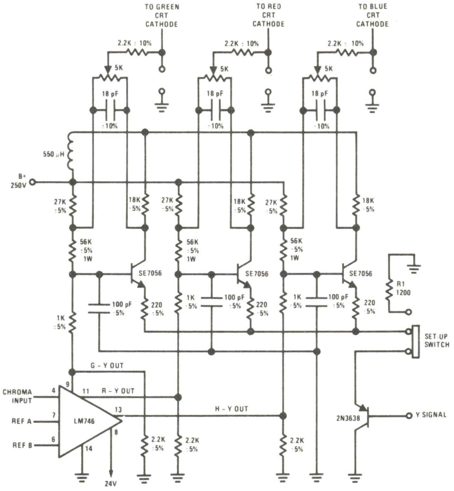
Pin numbers shown for Dual In Line Package

Dual-In-Line Package



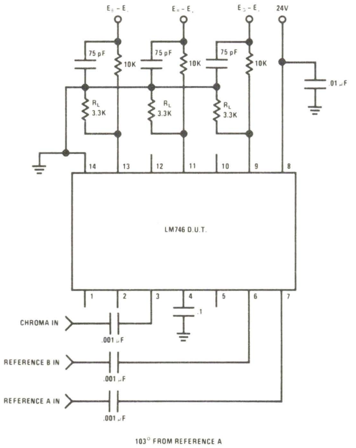
Order Number LM746N or LM746N-01
See Packages 22 and 24

typical application



Pin numbers shown for Dual In-Line Package

test circuit 1



absolute maximum ratings

Power Dissipation		Storage Temperature	$-65^{\circ}C$ to $+150^{\circ}C$
$T_A = 70^{\circ}C$ or less	450 mW	Supply Voltage	+30V
$T_A = 70^{\circ}C$ or more	Derate Linearly 8.2 mW/°C	Reference Input Volt (p-p)	5V
Operating Temperature	0°C to +70°C	Chroma Input Voltage (p-p)	5V

electrical characteristics ($T_A = 25^{\circ}C$) ($V_{CC} = 24V$) ($R_L = 3.3K$

PARAMETER	SYMBOL	TEST CKT	CONDITIONS	MIN	TYP	MAX	UNITS
STATIC							
Supply Current	I_S	1	$e_C = 0$ $R_L = 1M$	5.5	9.0	12.5	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 1M$ $T_A = 70^{\circ}C$		9.0	13.0	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 3.3k$	16.5	22	25.5	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 3.3k$ $T_A = 70^{\circ}C$		22		mA
Power Dissipation	P_D	1	$e_C = 0$		340	430	mW
Power Dissipation	P_D	1	$e_C = 0$ $T_A = 70^{\circ}C$		340	445	mW
DC Output Volts	V9, V11, V13	1	$e_C = 0$ $R_L = 3.3k$	13.2	14.5	15.8	V
DC Output Volts	V9, V11, V13	1	$e_C = 0$ $T_A = 70^{\circ}C$ $R_L = 3.3k$	13.0	14.5	16.0	V
Absolute Value of DC Difference Voltage Between any 2 Output Terminals	$\lvert \Delta V_O \rvert$		$e_C = 0$ $R_L = 3.3k$		.15	.6	V
Temperature Coefficient			$e_C = 0$	−5.0	−.3	+5.0	mV/°C
DYNAMIC							
Chroma Input Voltage Sensitivity	e_C	1	$E_B - E_Y = 5\ V_{p\text{-}p}$		.4	.7	$V_{p\text{-}p}$
$E_R - E_Y$ Output Voltage	V11	1	$E_B - E_Y = 5\ V_{p\text{-}p}$	3.5	3.8	4.2	$V_{p\text{-}p}$
$E_G - E_Y$ Output Voltage	V9	1	$E_B - E_Y = 5\ V_{p\text{-}p}$	.75	1.0	1.25	$V_{p\text{-}p}$
Maximum $E_B - E_Y$ Output Voltage	V13	1	$e_C = 1.5\ V_{p\text{-}p}$	8.0	10.0		$V_{p\text{-}p}$
$E_B - E_Y$ Demod Angle Relative to $E_R - E_Y$	$E_R\phi$	1	$E_B - E_Y = 5\ V_{p\text{-}p}$	101	106	111	degrees
$E_B - E_Y$ Demod Angle Relative to $E_G - E_Y$	$E_G\phi$	1	$E_B - E_Y = 5\ V_{p\text{-}p}$	−96	−104	−112	degrees
AC Unbalance @ Any Output Terminal		1	$e_C = 0$		.1	.8	$V_{p\text{-}p}$

Consumer Circuits

LM1303 stereo preamplifier

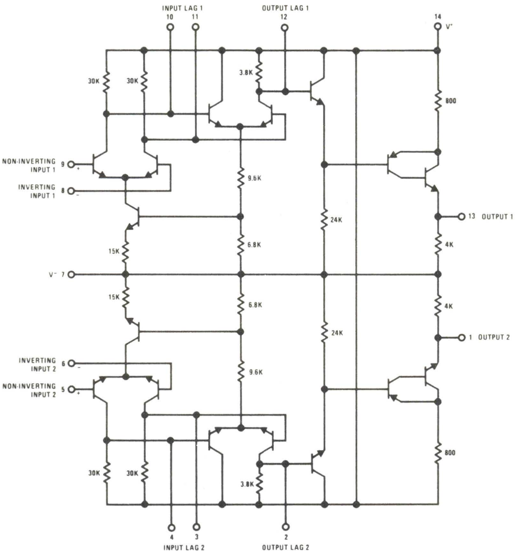
general description

The LM1303 consists of two identical operational amplifiers constructed on a single silicon chip. Intended for amplification of low-level stereo signals, the LM1303 features low input noise voltage, high open-loop voltage gain, large output voltage swing and short circuit protection.

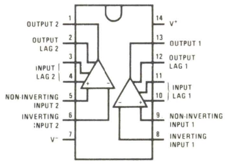
features

- Large Output Voltage Swing 4.0V rms min
- High Open-Loop Voltage Gain 6,000 min
- Channel Separation 60 dB min at 10 kHz

schematic and connection diagrams



Dual-In-Line Package

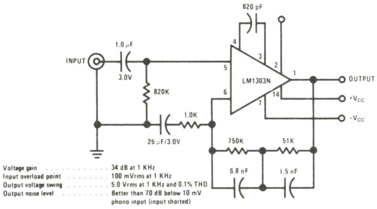


TOP VIEW

Order Number LM1303N
See Package 22

typical application and characteristic

Magnetic Phono Playback Preamplifier/R IAA Equalized



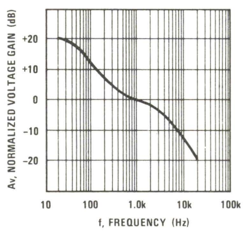


FIGURE 1

absolute maximum ratings

Supply Voltage	±15V
Power Dissipation (Note 1)	415 mW
Operating Temperature Range	0 to 75°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	MIN	TYP	MAX	UNITS
Input Offset Voltage		1.5	10	mV
Input Offset Current		0.2	0.4	μA
Input Bias Current		1.0	10	μA
Supply Current Both Amplifiers V_{OUT} = 0V			15	mA
Large Signal Voltage Gain	6,000	10,000		V/V
Channel Separation f = 10 kHz	60	70		dB
Output Voltage Swing R_L = 10 kΩ	4.0	5.5		V_{rms}

Note 1: The maximum junction temperature of the LM1303 is 100°C. For operating at elevated temperatures, devices must be derated based on a thermal resistance of 150°C/W, junction to ambient.

Note 2: These specifications apply for V_S = ±13V and T_A = 25°C, unless otherwise specified.

typical application and characteristic

Tape Head Playback Preamplifier/NAB Equalization

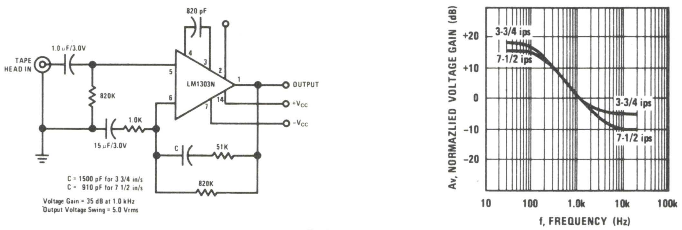
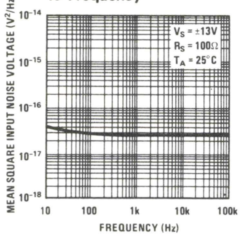


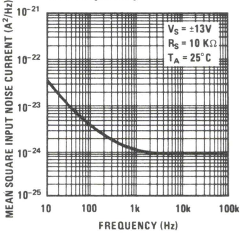
FIGURE 2

typical performance characteristics

Input Noise Voltage vs Frequency



Input Noise Current vs Frequency



Consumer Circuits

LM1304/LM1305/LM1307/LM1307E
FM multiplex stereo demodulator

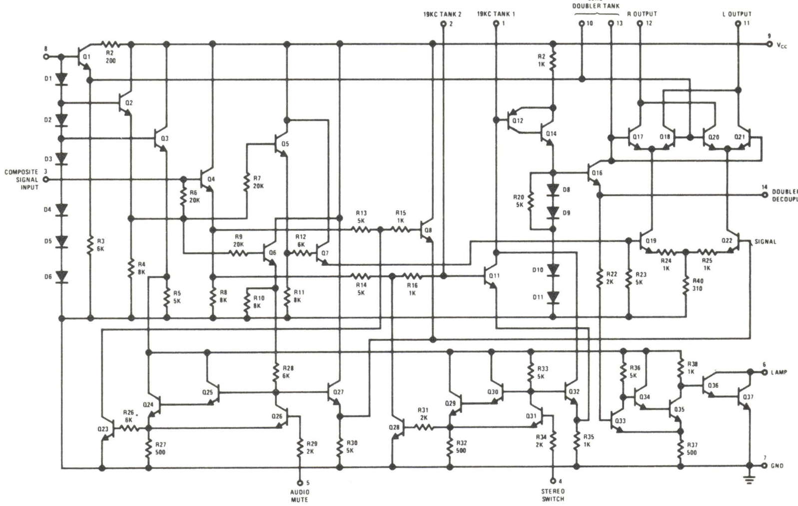
general description

The LM1304, LM1305, LM1307 and LM1307E are designed to derive the left and right channel audio information from the detected composite stereo signal. The LM1304 eliminates the need for an external stereo-channel separation control. The LM1305 is similar to the LM1304 but permits the use of an external stereo-channel separation control for maximum separation. The LM1307 is also similar to the LM1304 but does not have the audio mute control, or the stereo/mono switch. The LM1307E is similar to the LM1307 but has the option of emitter-follower output drivers for buffers or high current applications.

features

- Operation over a wide power supply range
- Built in stereo-indicator lamp driver — 100 mA typical
- Automatic switching between stereo and monaural
- Audio mute control

circuit schematics



LM1304

Order Number LM1304N or LM1305N or LM1307N or LM1307EN See Package 22

Order Number LM1304N-01 or LM1305N-01 or LM1307N-01 or LM1307EN-01 See Package 24

absolute maximum ratings

Power Supply Voltage	+22V
Lamp Driver Current	120 mA
Power Dissipation	625 mW
Derate Above T_A = +25°C	5.0 mW/°C
Operating Temperature Range (Ambient)	0°C to +75°C
Storage Temperature Range	−65°C to +150°C
Output Current (LM1307E)	25 mA
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (V_{CC} = 12V, T_A = 25°C, 75 µs de-emphasis unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Impedance	f = 1 kHz	12	20		kΩ
Stereo Channel Separation (Note 1)	f = 100 Hz		35		dB
(Note 3)	f = 1 kHz	30	45		dB
	f = 10 kHz		30		dB
Channel Balance	Monaural Input = 200 mV		0.2	1.0	dB
Total Harmonic Distortion (Note 1)	f_{MOD} = 1 k_c		0.5	1.0	%
Ultrasonic Frequency Rejection	19 kHz		30		dB
(Note 2)	38 kHz	20	25		dB
Inherent SCA Rejection (Without De-Emphasis)	60 kHz, 67 kHz, 74 kHz		50		dB
Lamp Indicator	R_A = 180Ω				
	Min 19 kHz Input Level for Lamp On		16	25	mVrms
	Max 19 kHz Input Level for Lamp Off	5.0	14		mVrms
Power Dissipation	Without Lamp		150	300	mW
Audio Muting (LM1304/5 Only)					
	Mute On (Pin 5 Voltage)	0.6	.8	1.0	V
	Mute Off (Pin 5 Voltage)	1.3	1.6	2.0	V
	Attenuation in Mute Mode		55		dB
Stereo-Monaural Switching	Stereo (Pin 4 Voltage)	1.3	1.6	2.0	V
(LM1304/5 Only)	Monaural (Pin 5 Voltage)	0.6	.8	1.0	V

Note 1: Measurement made with standard multiplex composite signal. L = 1, R = 0 or L = 0, R = 1; composite signal defined as 564 mV peak to peak (100 mVrms as read on Ballantine 310-A voltmeter) with a 20 mVrms 19 kHz pilot carrier.

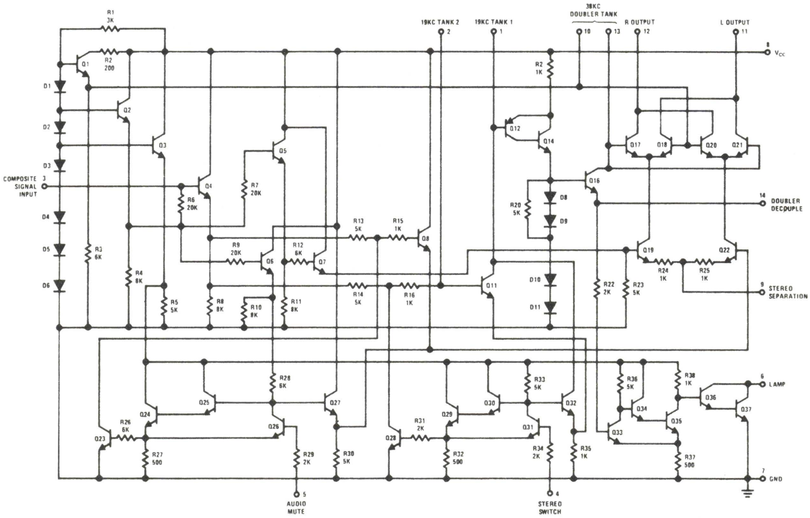
Note 2: Referenced to 1 kHz output signal with signal per Note 1.

Note 3: Stereo channel separation is adjusted for maximum separation in the LM1305 with a resistor from Pin 9 to GND.

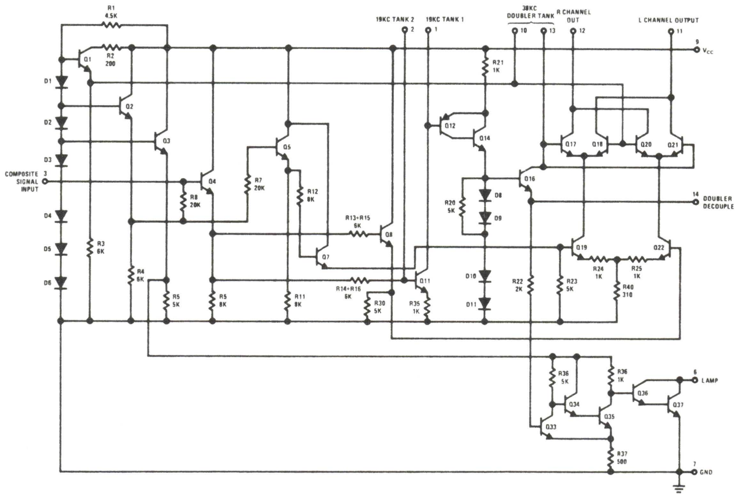
(R_A = 180Ω, All voltages measured with respect to GND)
(V_{CC} = 12V, 2.7 kΩ in series w/Pin 8)

Pins	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LM1304	12	2.3	3.0	1.9	1.9	0.8	0	4.6	12	3.9	9.7	9.7	3.9	1.9
LM1305	12	2.3	3.0	1.9	1.9	0.8	0	12	0.36	3.9	9.7	9.7	3.9	1.9
LM1307	12	2.3	3.0	–	–	0.8	0	–	12	3.9	9.7	9.7	3.9	1.9
LM1307E	12	2.3	3.0	–	.8	12	0	9.7	9.0	9.0	9.7	3.9	3.9	1.9

circuit schematics (con't)

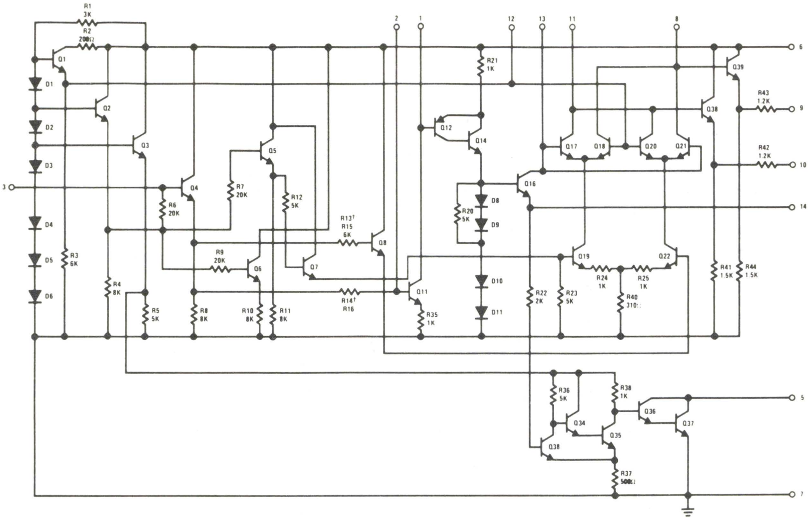


LM1305



LM1307

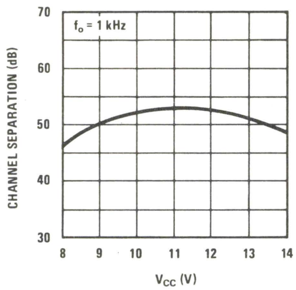
circuit schematics (con't)



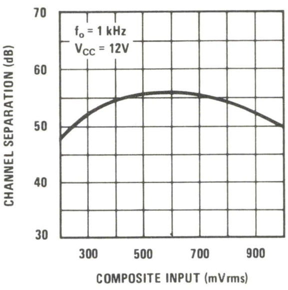
LM1307E

typical performance characteristics

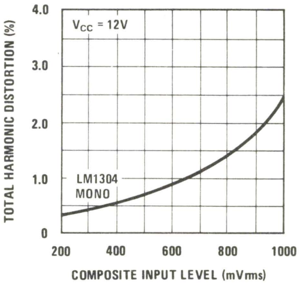
Channel Separation vs V_{CC}



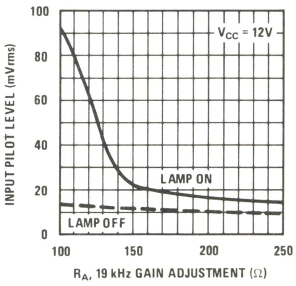
Channel Separation vs Composite Input Level



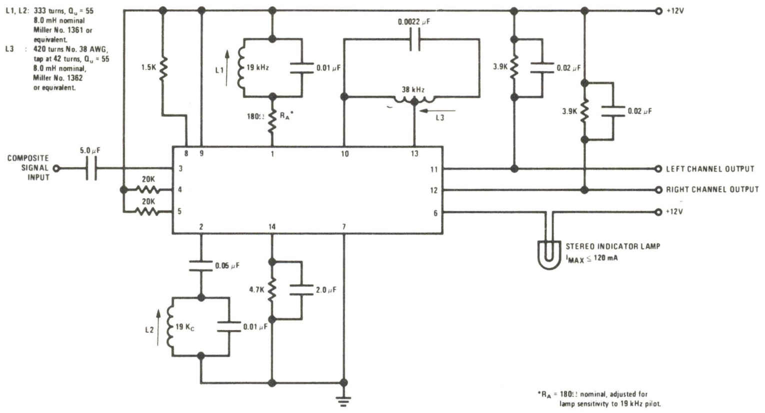
Total Harmonic Distortion vs Composite Input Level



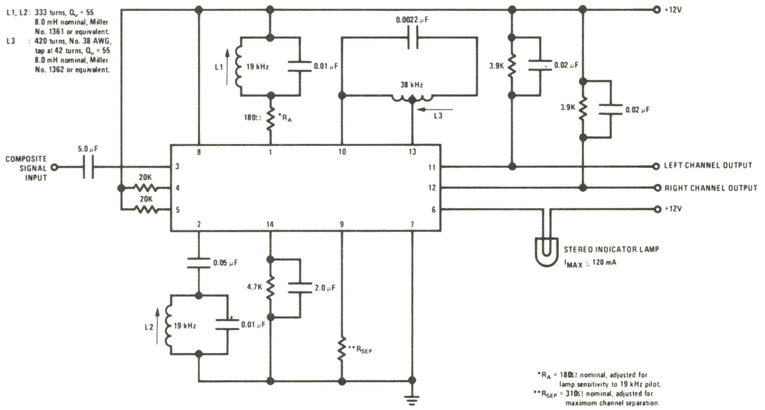
Multiplex Sensitivity vs 19 kHz Gain Adjustment



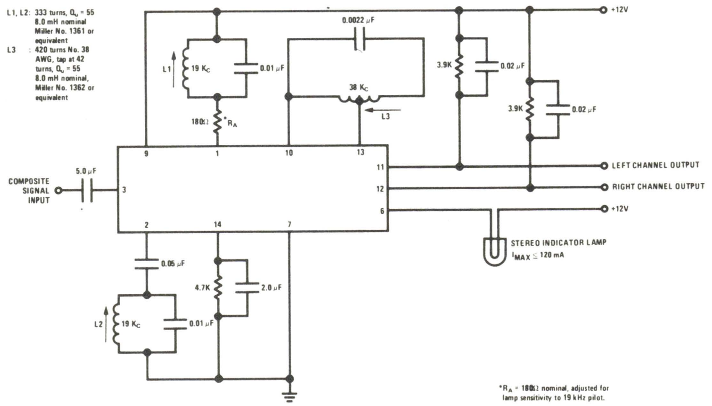
circuit configurations



LM1304 Typical Circuit Configuration

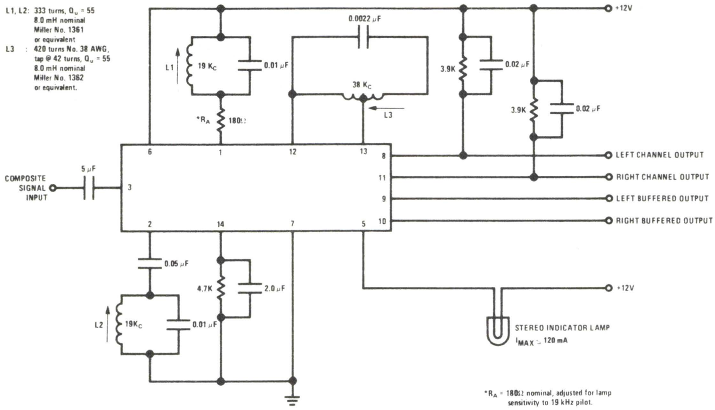


LM1305 Typical Circuit Configuration



LM1307 Typical Circuit Configuration

circuit configurations (con't)



LM1307E Typical Circuit Configuration

Consumer Circuits

LM1310/LM1310E phase locked loop FM stereo demodulator

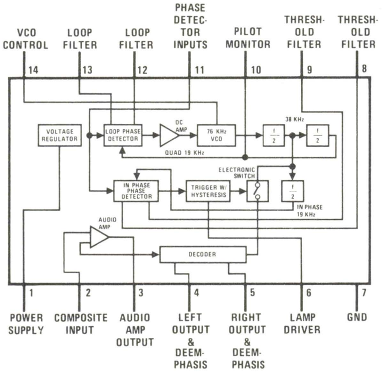
general description

The LM1310 and LM1310E are integrated FM stereo demodulators using phase locked loop techniques to regenerate the 38 kHz subcarrier. The LM1310 is a 14 pin version while the LM1310E offers buffered emitter follower outputs in a 16 pin package. A third version, the LM1800, is also available (see separate data sheet) which adds superb power supply rejection to the basic phase locked decoder circuit. The features available in these integrated circuits make possible a system delivering high fidelity sound within the cost restraints of inexpensive stereo receivers.

features

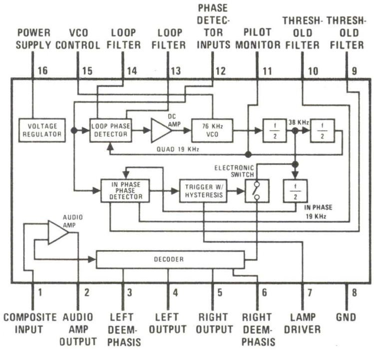
- Automatic stereo/monaural switching
- No coils, all tuning performed with single potentiometer
- Wide supply operating voltage range
- Excellent channel separation
- Emitter follower output buffers (on LM1310E)

connection diagrams



TOP VIEW

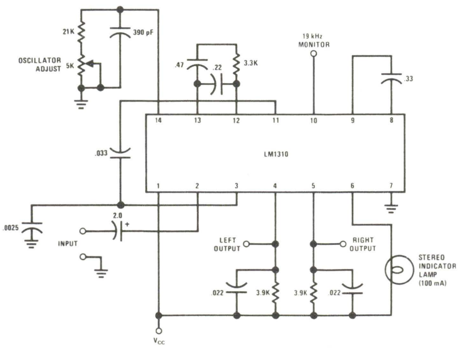
Order Number LM1310EN
See Package 22

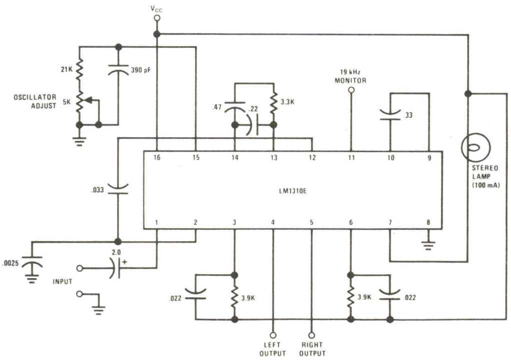


TOP VIEW

Order Number LM1310N
See Package 23

typical applications





absolute maximum ratings

Supply Voltage	24V
Power Dissipation (Note 3)	575 mW
Operating Temperature Range	0°C to +70°C
Operating Supply Voltage Range	+10V to +24V
Storage Temperature Range	−55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current					
LM1310E	Lamp "off"		22	30	mA
LM1310	Lamp "off"		19	30	mA
Lamp Driver Saturation	100 mA Lamp Current		1.3	1.8	V
Lamp Driver Leakage			1		nA
Pilot Level for Lamp "on"	Pin 11 Adjusted to 19.00 kHz		16	23	mVrms
Pilot Level for Lamp "off"	Pin 11 Adjusted to 19.00 kHz	3	8		mVrms
Stereo Lamp Hysteresis		3	6		dB
Stereo Channel Separation	100 Hz (Note 2)		40		dB
	1000 Hz (Note 2)	30	45		dB
	10000 Hz (Note 2)		45		dB
Monaural Channel Unbalance	200 mVrms, 1000 Hz Input		.3	1.5	dB
Recovered Audio	200 mVrms, 400 Hz Input	100		190	mVrms
Total Harmonic Distortion	500 mVrms, 1000 Hz Input			1	%
Capture Range	25 mVrms of Pilot	±2		±6	% of f_O
Ultrasonic Freq. Rejection	Combined 19 and 38 kHz, Ref. to Outputs		33		dB
Dynamic Input Resistance		20	45		kΩ
Dynamic Output Resistance	(LM1310E Only)	900	1300	2000	Ω
SCA Rejection	200 mVrms Composite at 67 kHz		50		dB

Note 1: T = 25°C and V^+ = 12V unless otherwise specified.

Note 2: The stereo input signal is made by summing 123 mVrms LEFT or RIGHT modulated signal with 25 mVrms of 19 kHz pilot tone, measuring all voltages with an average responding meter calibrated in rms. The resulting waveform is about 800 mV_{P-P}.

Note 3: The maximum junction temperature is +125°C and the package should be derated at +175°C/W junction to ambient.

Consumer Circuits

LM1351 FM detector, limiter and audio amplifier

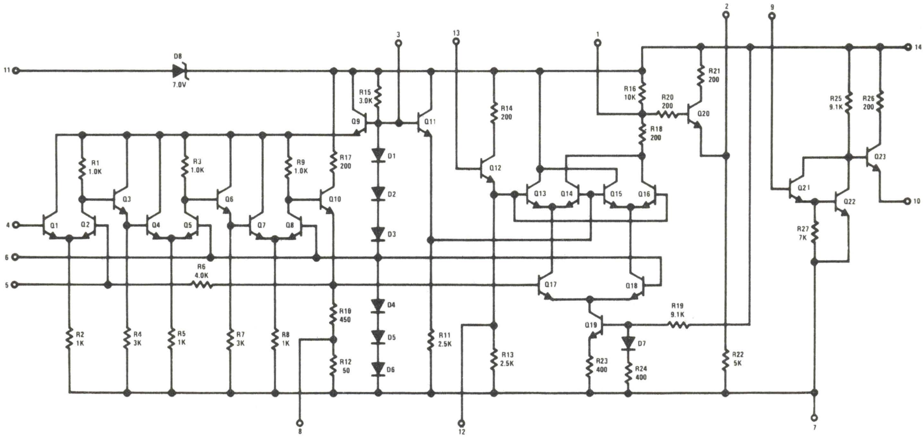
general description

The LM1351 is a monolithic integrated circuit FM detector, limiter and audio amplifier that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector. The audio amplifier is capable of driving a single external transistor class A-audio output stage.

features

- A direct replacement for MC1351
- Simple detector alignment: one coil or ceramic filter.
- Sensitivity: 3 dB limiting voltage 80 μV typ.
- Low harmonic distortion
- High IF voltage gain
- High audio preamplifier open loop gain

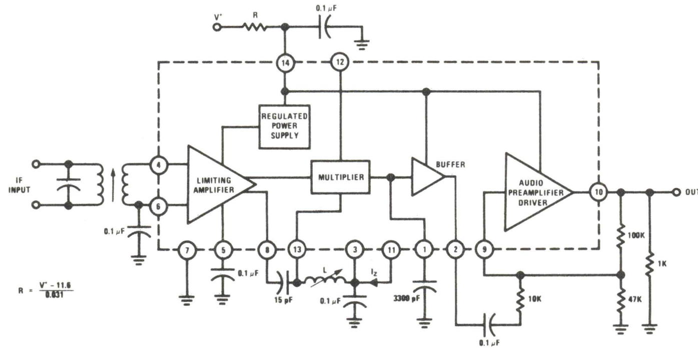
schematic diagram



Order Number LM1351N
See Package 22

Order Number LM1351N-01
See Package 24

block diagram



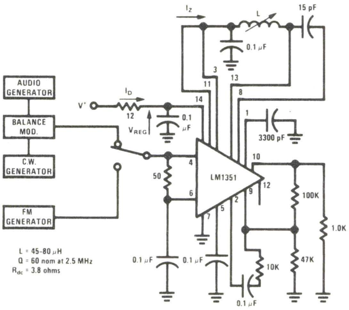
absolute maximum ratings

Supply Voltage	16V
Input Signal Voltage (Pin 4)	0.7 Vrms
Power Dissipation	
T_A = 25°C or less	850 mW
T_A = 25°C or more	Derate Linearly 6.67 mW/°C
Operating Temperature Range	0°C to 75°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V_{CC} = 12V, unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	LIMITS MIN	TYP	MAX	UNITS
STATIC CHARACTERISTICS						
Supply Current	I_{14}	I_Z = 5 mA		31		mA
Power Dissipation	P_D	I_Z = 5 mA		300	375	mW
Nominal Zener Voltage	V_{14}	I_Z = 5 mA		11.6		V
DYNAMIC CHARACTERISTICS f_0 = 4.5 MHz, ΔF = ±25 kHz, unless otherwise noted						
Amplifier Voltage Gain	$A_{V(IF)}$	$V_{IN} \leq 0.3$ mVrms		65		dB
Audio Preamplifier Open Loop Gain	$A_{V(AF)}$	V_{IN} = 500 mV @ 400 Hz		40		dB
Input Limiting Threshold	$V_{IN(LIM)}$	FM = 400 Hz		80	160	μVrms
Recovered Audio Output	$V_{O(AF)}$		0.35	0.50		Vrms
Recovered Audio Output	$V_{O(AF)}$	f_0 = 5.5 MHz, AF = ±50 kHz		0.8		Vrms
Total Harmonic Distortion	T_{HD}	Q_L = 24, Δf = 7.5 kHz		1.0		%
Maximum Undistorted Audio Output Voltage	V_{OMAX}	Q_L = 24, Audio Gain = 10		3.5		Vrms
AM Suppression	AMR	AM: 1 kHz @ 30%, V_{IN} = 20 mV	38	45		dB

test circuit



Consumer Circuits

LM1596/LM1496 balanced modulator-demodulator

general description

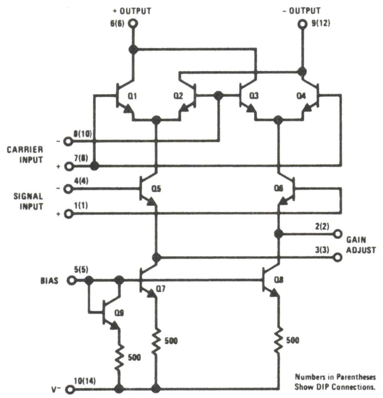
The LM1596/LM1496 are double balanced modulator-demodulators which produce an output voltage proportional to the product of an input (signal) voltage and a switching (carrier) signal. Typical applications include suppressed carrier modulation, amplitude modulation, synchronous detection, FM or PM detection, broadband frequency doubling and chopping.

The LM1596 is specified for operation over the −55°C to +125°C military temperature range. The LM1496 is specified for operation over the 0°C to +70°C temperature range.

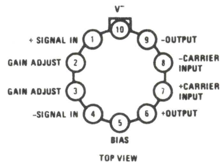
features

- Excellent carrier suppression
  - 65 dB typical at 0.5 MHz
  - 50 dB typical at 10 MHz
- Adjustable gain and signal handling
- Fully balanced inputs and outputs
- Low offset and drift
- Wide frequency response up to 100 MHz

schematic and connection diagrams



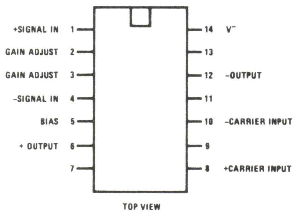
Metal Can Package



Note: Pin 10 is connected electrically to the case through the device substrate.

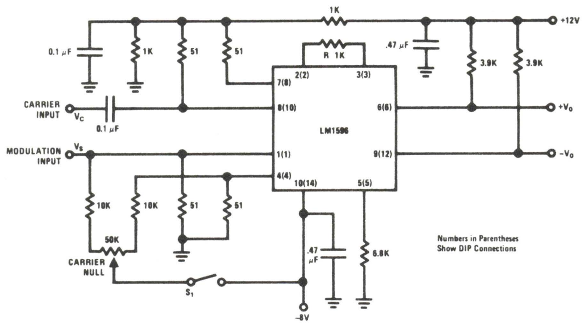
Order Number LM1496H or LM1596H
See Package 11

Dual-In-Line Package



Order Number LM1496N
See Package 22

typical application and test circuit



NOTE: S_1 is Closed for "Adjusted" Measurements.

Suppressed Carrier Modulator

absolute maximum ratings

Internal Power Dissipation (Note 1)	500 mW
Applied Voltage (Note 2)	30V
Differential Input Signal ($V_7 - V_8$)	±5.0V
Differential Input Signal ($V_4 - V_1$)	$\pm(5+I_5R_e)$ V
Input Signal ($V_2 - V_1$, $V_3 - V_4$)	5.0V
Bias Current (I_5)	12 mA
Operating Temperature Range LM1596	−55°C to +125°C
LM1496	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, unless otherwise specified, see test circuit)

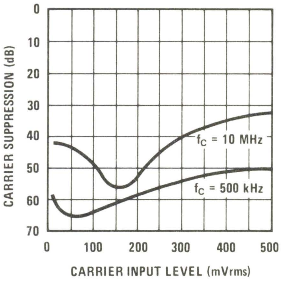
PARAMETER	CONDITIONS	LM1596 MIN	LM1596 TYP	LM1596 MAX	LM1496 MIN	LM1496 TYP	LM1496 MAX	UNITS
Carrier Feedthrough	V_C = 60 mVrms sine wave f_C = 1.0 kHz, offset adjusted		40			40		μVrms
	V_C = 60 mVrms sine wave f_C = 10 MHz, offset adjusted		140			140		μVrms
	V_C = 300 mV_{pp} square wave f_C = 1.0 kHz, offset adjusted		0.04	0.2		0.04	0.2	mVrms
	V_C = 300 mV_{pp} square wave f_C = 1.0 kHz, offset not adjusted		20	100		20	150	mVrms
Carrier Suppression	f_S = 10 kHz, 300 mVrms f_C = 500 kHz, 60 mVrms sine wave offset adjusted	50	65		50	65		dB
	f_S = 10 kHz, 300 mVrms f_C = 10 MHz, 60 mVrms sine wave offset adjusted		50			50		dB
Transadmittance Bandwidth	R_L = 50Ω Carrier Input Port, V_C = 60 mVrms sine wave f_S = 1.0 kHz, 300 mVrms sine wave		300			300		MHz
	Signal Input Port, V_S = 300 mVrms sine wave $V_7 - V_8$ = 0.5Vdc		80			80		MHz
Voltage Gain, Signal Channel	V_S = 100 mVrms, f = 1.0 kHz $V_7 - V_8$ = 0.5Vdc	2.5	3.5		2.5	3.5		V/V
Input Resistance, Signal Port	f = 5.0 MHz $V_7 - V_8$ = 0.5 Vdc		200			200		kΩ
Input Capacitance, Signal Port	f = 5.0 MHz $V_7 - V_8$ = 0.5 Vdc		2.0			2.0		pF
Single Ended Output Resistance	f = 10 MHz		40			40		kΩ
Single Ended Output Capacitance	f = 10 MHz		5.0			5.0		pF
Input Bias Current	$(I_1 + I_4)/2$		12	25		12	30	μA
Input Bias Current	$(I_7 + I_8)/2$		12	25		12	30	μA
Input Offset Current	$(I_1 - I_4)$		0.7	5.0		0.7	5.0	μA
Input Offset Current	$(I_7 - I_8)$		0.7	5.0		5.0	5.0	μA
Average Temperature Coefficient of Input Offset Current	$(-55°C < T_A < +125°C)$ $(0°C < T_A < +70°C$		2.0			2.0		nA/°C nA/°C
Output Offset Current	$(I_6 - I_9)$		14	50		14	60	μA
Average Temperature Coefficient of Output Offset Current	$(-55°C < T_A < +125°C)$ $(0°C < T_A < +70°C)$		90			90		nA/°C nA/°C
Signal Port Common Mode Input Voltage Range	f_S = 1.0 kHz		5.0			5.0		V_{p-p}
Signal Port Common Mode Rejection Ratio	$V_7 - V_8$ = 0.5 Vdc		−85			−85		dB
Common Mode Quiescent Output Voltage			8.0			8.0		Vdc
Differential Output Swing Capability			8.0			8.0		V_{p-p}
Positive Supply Current	$(I_6 + I_9)$		2.0	3.0		2.0	3.0	mA
Negative Supply Current	(I_{10})		3.0	4.0		3.0	4.0	mA
Power Dissipation			33			33		mW

Note 1: LM1596 rating applies to case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperature above 75°C. LM1496 rating applies to case temperatures to +70°C.

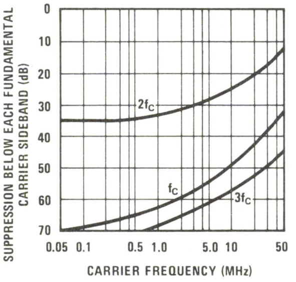
Note 2: Voltage applied between pins 6-7, 8-1, 9-7, 9-8, 7-4, 7-1, 8-4, 6-8, 2-5, 3-5.

typical performance characteristics

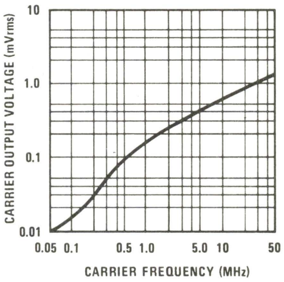
Carrier Suppression vs Carrier Input Level



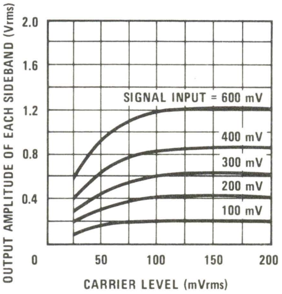
Carrier Suppression vs Frequency



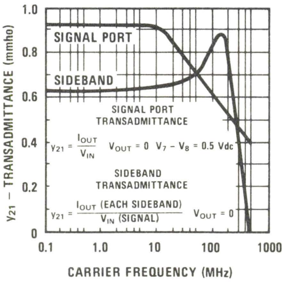
Carrier Feedthrough vs Frequency



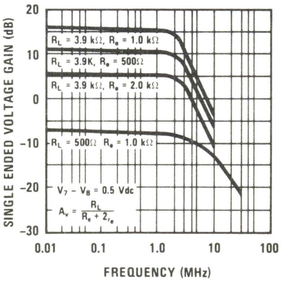
Sideband Output vs Carrier Levels



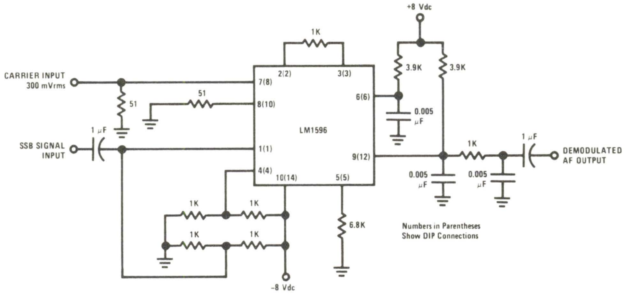
Sideband and Signal Port Transadmittances vs Frequency



Signal-Port Frequency Response



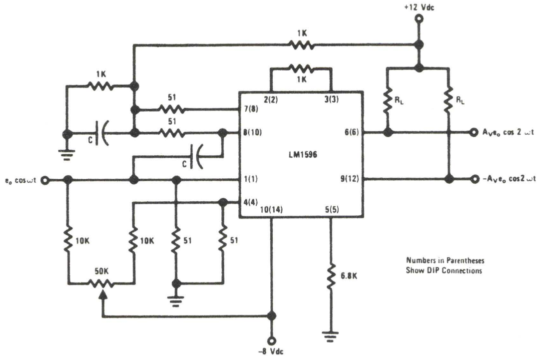
typical applications (con't)



SSB Product Detector

This figure shows the LM1596 used as a single sideband (SSB) suppressed carrier demodulator (product detector). The carrier signal is applied to the carrier input port with sufficient amplitude for switching operation. A carrier input level of 300 mVrms is optimum. The composite SSB signal is applied to the signal input port with an amplitude of 5.0 to 500 mVrms. All output signal components except the desired demodulated audio are filtered out, so that an offset adjustment is not required. This circuit may also be used as an AM detector by applying composite and carrier signals in the same manner as described for product detector operation.

typical applications (con't)



Broadband Frequency Doubler

The frequency doubler circuit shown will double low-level signals with low distortion. The value of C should be chosen for low reactance at the operating frequency.

Signal level at the carrier input must be less than 25 mV peak to maintain operation in the linear region of the switching differential amplifier. Levels to 50 mV peak may be used with some distortion of the output waveform. If a larger input signal is available a resistive divider may be used at the carrier input, with full signal applied to the signal input.

Consumer Circuits

LM1800 phase locked loop FM stereo demodulator

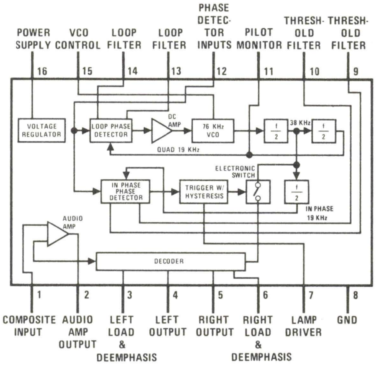
general description

The LM1800 is a second generation integrated FM stereo demodulator using phase locked loop techniques to regenerate the 38 kHz subcarrier. The numerous features integrated on the die make possible a system delivering high fidelity sound while still meeting the cost requirements of inexpensive stereo receivers.

features

- Automatic stereo/monaural switching
- 45 dB power supply rejection
- No coils, all tuning performed with single potentiometer
- Wide operating supply voltage range
- Excellent channel separation
- Emitter follower output buffers

connection diagram

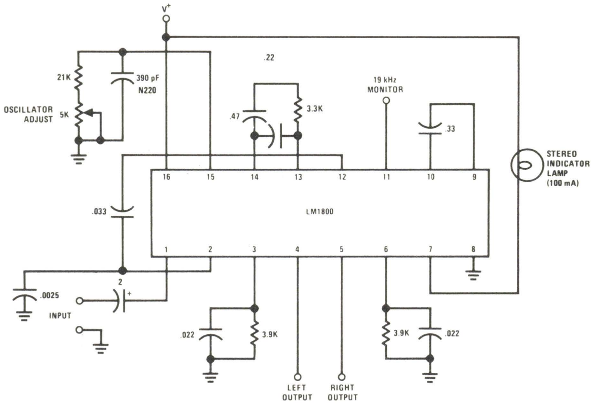


TOP VIEW

Order Number LM1800N

See Package 23

typical application



absolute maximum ratings

Supply Voltage	24V
Power Dissipation (Note 3)	575 mW
Operating Temperature Range	0°C to +70°C
Operating Supply Voltage Range	+10V to +24V
Storage Temperature Range	−55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	Lamp "off"		21	30	mA
Lamp Driver Saturation	100 mA Lamp Current		1.3	1.8	V
Lamp Driver Leakage			1		nA
Pilot Level for Lamp "on"	Pin 11 Adjusted to 19.00 kHz		16	23	mVrms
Pilot Level for Lamp "off"	Pin 11 Adjusted to 19.00 kHz	3	8		mVrms
Stereo Lamp Hysteresis		3	6		dB
Stereo Channel Seperation	100 Hz (Note 2)		40		dB
	1000 Hz (Note 2)	30	45		dB
	10000 Hz (Note 2)		45		dB
Monaural Channel Unbalance	200 mVrms, 1000 Hz Input		.3	1.5	dB
Recovered Audio	200 mVrms, 400 Hz Input	140		260	mVrms
Total Harmonic Distortion	500 mVrms, 1000 Hz Input			1	%
Capture Range	25 mVrms of Pilot	±2		±6	% of f_O
Supply Ripple Rejection	600 mVrms of 200 Hz Ripple	35	45		dB
Dynamic Input Resistance		20	45		kΩ
Dynamic Output Resistance		900	1300	2000	Ω
SCA Rejection	200 mVrms composite at 67 kHz		50		dB
Ultrasonic Freq. Rejection	Combined 19 and 38 kHz, Ref. to Output		33		dB

Note 1: T = 25°C and V^+ = 12V unless otherwise specified.

Note 2: The stereo input signal is made by summing 123 mVrms LEFT or RIGHT modulated signal with 25 mVrms of 19 kHz pilot tone, measuring all voltages with an average responding meter calibrated in rms. The resulting waveform is about 800 mV_{P-P}.

Note 3: The maximum junction temperature is +125°C and the package should be derated at +175°C/W junction to ambient.

Consumer Circuits

LM1820 AM radio system

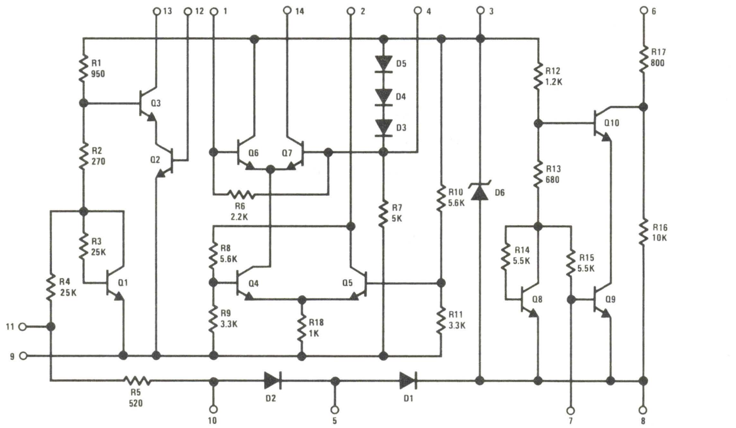
general description

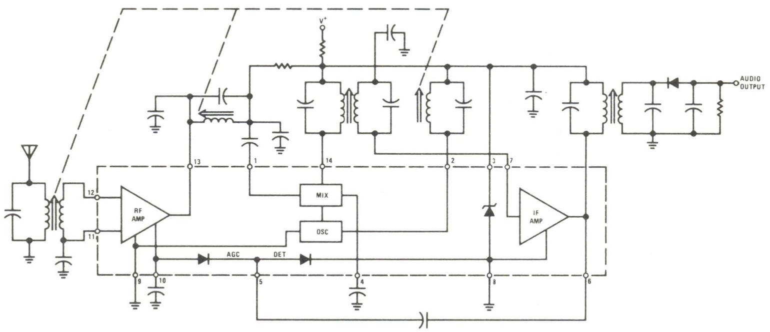
The LM1820 is a monolithic integrated circuit AM radio system. It includes two amplifiers a mixer-oscillator; an AGC detector and a zener regulator.

features

- Overvoltage protection
- Separately accessible amplifiers
- Regulated supply
- AGC for RF stage

schematic and block diagrams





Order Number LM1820N
See Package 22

absolute maximum ratings

Supply Voltage	16V
Current into Supply Terminal (Pin 3)	35 mA
Power Dissipation	
T_A = 25°C or Less	850 mW
T_A = 25°C or More	Derate Linearly 6.67 mW/°C
Operating Temperature Range	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V^+ = 12V, Figure 1)

PARAMETER	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
STATIC CHARACTERISTICS					
Supply Current (I)			18		mA
Zener Regulator (V_3)	$I_2 + I_3$ = 15 mA		7.1		V
Local Oscillator Current (I_2)	$I_2 + I_3$ = 15 mA		1.2		mA
IF Current (I_6)	$I_2 + I_3$ = 15 mA		4.5		mA
RF Current (I_{13})	$I_2 + I_3$ = 15 mA		5.6		mA
Mixer Current (I_{14})			300		μA
DYNAMIC CHARACTERISTICS					
RF Transconductance (i_{13}/e_{12})	f_{12} = 1 MHz, e_{12} = 100μV, e_5 = 0 S1 in Pos 1		120		mmhos
RF Input Resistance (R_{12})	f_{12} = 1 MHz, S1 in Pos 2		1		kΩ
IF Transconductance (i_6/e_7)	f_7 = 260 kHz, e_7 = 1 mVrms		90		mmhos
IF Input Resistance (R_7)	f_7 = 260 kHz		1		kΩ
Mixer Transconductance (i_{14}/e_1)	f_1 = 1 MHz, e_1 = 1 mVrms		2.5		mmhos
Mixer Input Resistance (R_1)	f_1 = 1 MHz		1.4		kΩ
Oscillator Voltage (e_2)			1.7		Vrms

test circuit

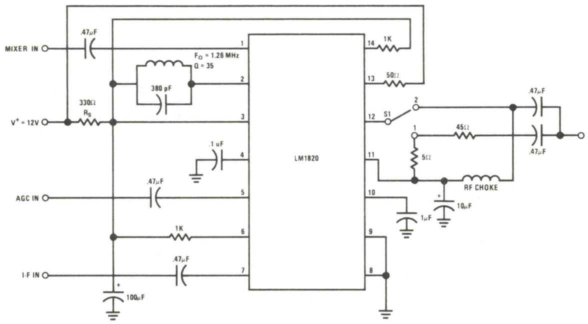


Figure 1.

Consumer Circuits

LM1841 FM detector and limiter

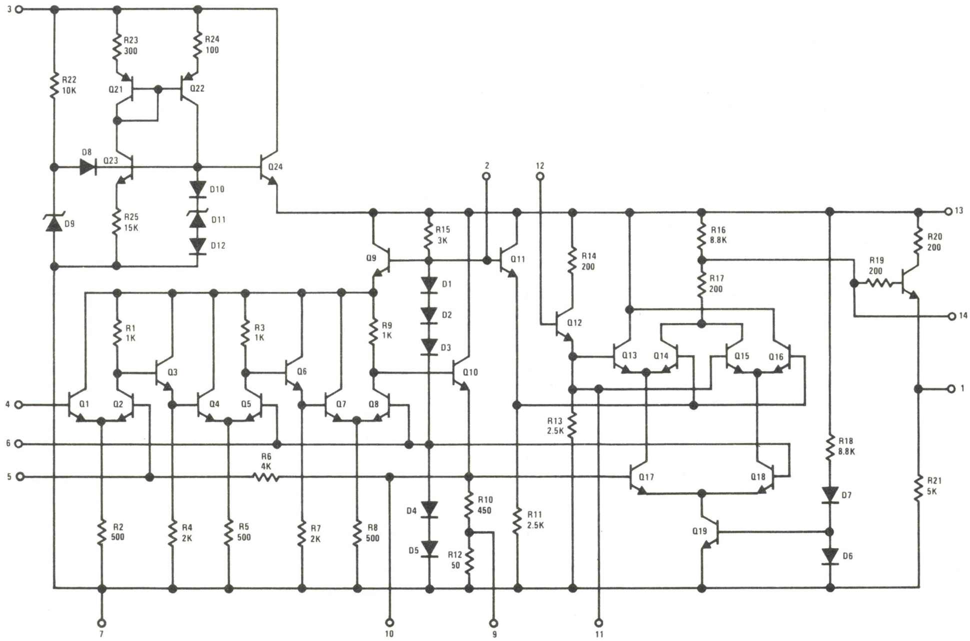
general description

The LM1841 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting, a balanced product detector and a 7.8V regulator.

features

- A direct replacement for ULN2136A
- Simple detector alignment: one coil
- Sensitivity: 3 dB limiting voltage 300 μV typ.
- Low harmonic distortion
- High IF voltage gain
- Regulated 7.8V output

schematic diagram



Order Number LM1841N
See Package 22

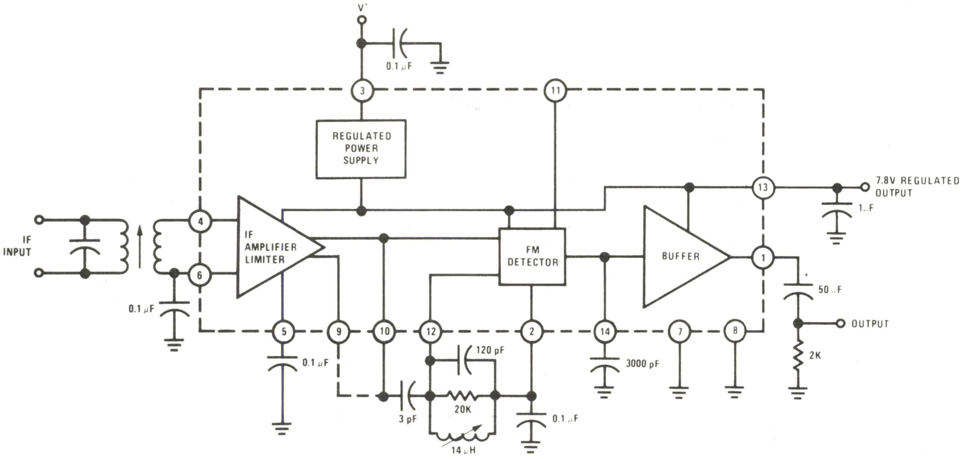
absolute maximum ratings

Supply Voltage	20V
Input Signal Voltage (Pin 4)	3.5V
Power Dissipation	
T_A = 25°C or Less	850 mW
T_A = 25°C or More	Derate Linearly 6.67 mW/°C
Operating Temperature Range	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V^+ = 12V unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
STATIC CHARACTERISTICS (amplifier and detector)					
Supply Current (I_3)	No Load at Pin 13	12	17	22	mA
Amplifier Input Reference (V_6)			1.45		V
Detector Input Reference (V_2)			3.65		V
Amplifier High Output Level (V_{10})		1.25	1.45	1.65	V
Amplifier Low Output Level (V_9)		0.125	0.145		V
Detector Output Level (V_1)		3	3.8	4.6	V
Temperature Stability of Detector Output Level ($\Delta V_1/\Delta T$)			+1		mV/°C
De-emphasis Resistance (R_d)			8.8		kΩ
STATIC CHARACTERISTICS (regulator)					
Output Voltage (V_{13})	i_{LOAD} = 20 mA		7.8		V
Line Regulation (V_{13})			5	10	mV/V
Temperature Stability (V_{13})			+1.6		mV/°C
DYNAMIC CHARACTERISTICS f_o = 4.5 MH, Δf = ±25 kHz, Peak Separation = 150 kHz, Source Resistance = 50Ω					
Amplifier Voltage Gain (A_{IF})	$V_{IN} \leq 0.3$ mVrms (Figure 1)		58		dB
Amplifier Output Voltage ($V_{10(IF)}$)	V_{IN} = 10 mV (Figure 1)		1.45		V_{P-P}
Input Limiting Threshold ($V_{IN(LIM)}$)	FM = 400 Hz (Figure 2)		300		μVrms
Recovered Audio Output ($V_{O(af)}$)	V_{IN} = 60 mV, FM = 400 Hz (Figure 2)		0.5		Vrms
Output Distortion (T_{HD})	100% FM Modulation (Figure 2)		1.5		%
AM Rejection (AMR)	AM: 1 kHz @ 30%, V_{IN} = 10 mV (Figure 2)		46		dB
DYNAMIC CHARACTERISTICS f_0 = 10.7 MHz, Δf = ±75 kHz, Peak Separation = 550 kHz, Source Resistance = 50Ω					
Amplifier Voltage Gain (A_{IF})	$V_{IN} \leq 0.3$ mVrms (Figure 1)		53		dB
Amplifier Output Voltage ($V_{10(IF)}$)	V_{IN} = 10 mV (Figure 1)		1.45		V_{P-P}
Input Limiting Threshold ($V_{IN(LIM)}$)	FM = 400 Hz (Figure 2)		400		μV
Recovered Audio Output ($V_{O(af)}$)	V_{IN} = 60 mV, FM = 400 Hz (Figure 2)		0.3		Vrms
Output Distortion (T_{HD})	100% FM Modulation (Figure 2)		1		%
AM Rejection (AMR)	AM: 1 kHz = 30%, V_{IN} = 10 mV (Figure 2)		40		dB

block diagram



test circuits

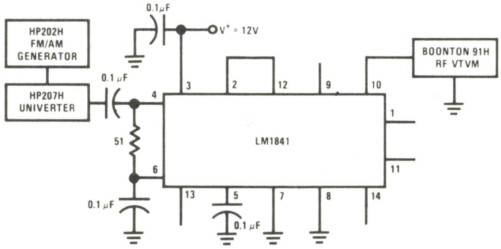


FIGURE 1.

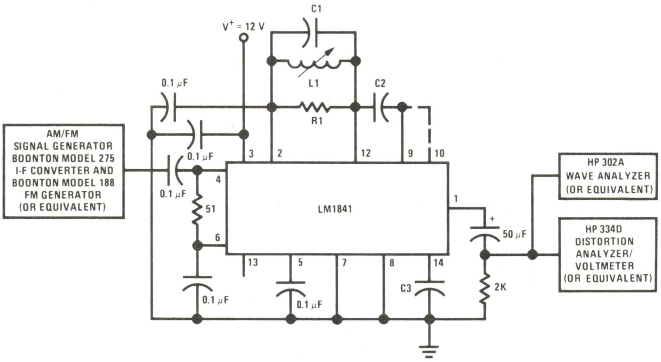


FIGURE 2.

COMPONENT VALUES

f	L1	C1	R1	Q(R1,L1)	C2	C3
MHz	μH	pF	kΩ		pF	μF
4.5	14	120	20	30	3.0	0.003
5.5	8.0	100	20	30	3.0	0.003
10.7	2.0	120	3.9	20	4.7	0.01

Consumer Circuits

LM1845 signal processing system

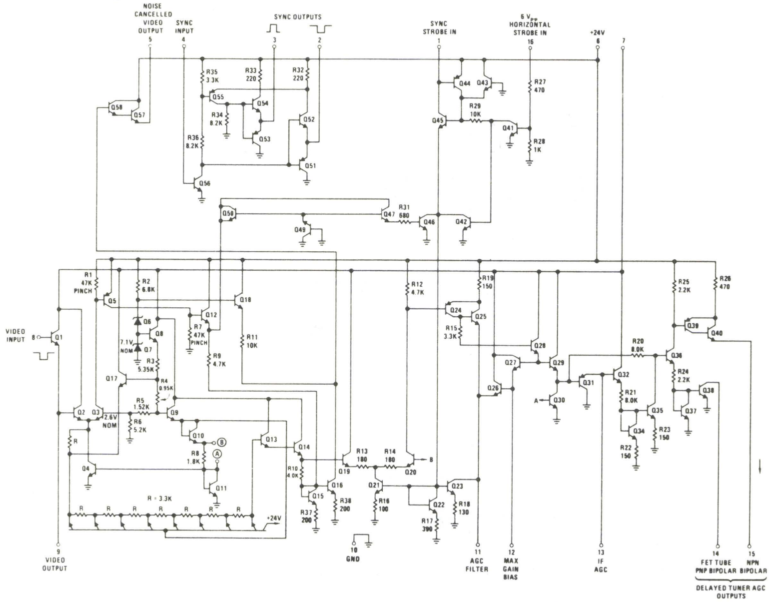
general description

The LM1845 is a signal processing system for television receivers which performs the functions of AGC and sync separation. It provides both positive and negative going sync signals and includes an internal AGC amplifier with noise cancelling. AGC outputs are available for both IF and tuner.

features

- Video internally delayed for total noise inversion
- Low impedance noise cancelled positive and negative going sync outputs
- No noise threshold or AGC detector level adjustment
- Low impedance video output for driving luminance channel or a video output stage
- Two delayed tuner AGC outputs; one for an NPN bipolar tuner and one for a FET, tube, or PNP

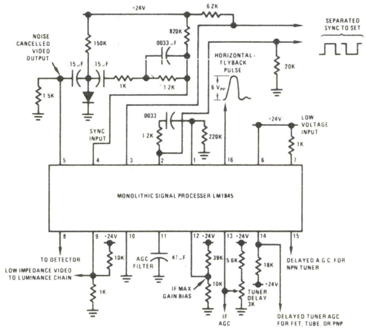
schematic diagram



Order Number LM1845N
See Package 23

Order Number LM1845N-01
See Package 25

typical circuit configuration



absolute maximum ratings

Supply Voltage	30V
Power Dissipation (Note 2)	625 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	–55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
AGC Threshold		4.65		5.3	V
Threshold Separation			1.7		V
Negative Sync Output (Low)	I_{P4} = 100 μA			2.5	V
Negative Sync Output (High)	V_{P4} = 0V	23.9			V
Positive Sync Output (Low)	V_{P4} = 0V			0.1	V
Positive Sync Output (High)	I_{P4} = 100 μA	20.5			V
AGC Filter Discharge Current			1.70		mA
AGC Filter Charge Current			20		mA
Reverse Tuner AGC Maximum Current			3.2		mA
Forward Tuner AGC Maximum Current			9.8		mA
Internal AC Coupled Noise Gate Lockout Interval		1		55	μs
Supply Current	1 Kohm between P6 and P7		10		mA

Note 1: T = 25°C and V_{CC} = 24V.

Note 2: The maximum junction temperature of the LM1845 is 125°C. For operating at elevated temperatures the derating factor is 175°C/W junction to ambient.

Consumer Circuits

LM2111 FM detector and limiter

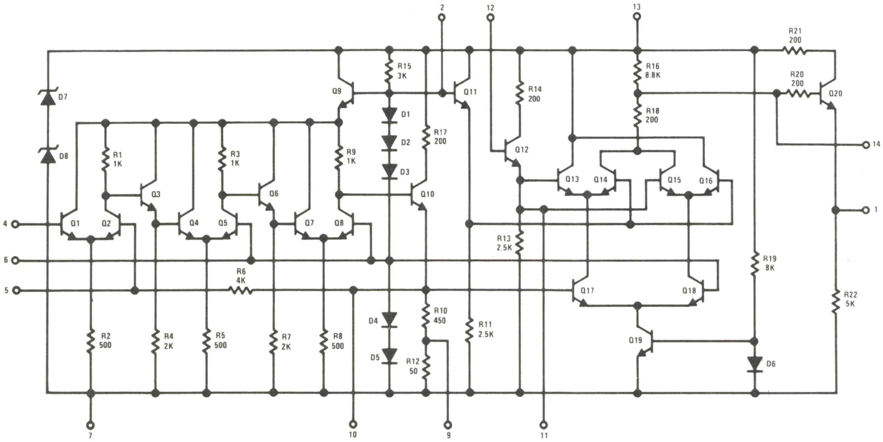
general description

The LM2111 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector.

features

- A direct replacement for ULN2111A and MC1357
- Simple detector alignment: one coil or ceramic filter
- Sensitivity: 3 dB limiting voltage 300 μV typ.
- Low harmonic distortion
- High IF voltage gain

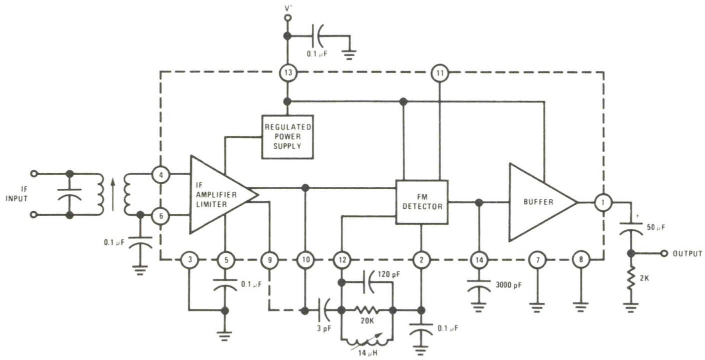
schematic diagram



Order Number LM2111N
See Package 22

Order Number LM2111N-01
See Package 24

block diagram



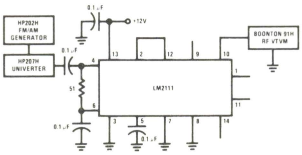
absolute maximum ratings

Supply Voltage	15V
Input Signal Voltage (Pin 4)	3.5V
Power Dissipation	
T_A = 25°C or less	850 mW
T_A = 25°C or more	Derate Linearly 6.67 mW/°C
Operating Temperature Range	0°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V_{CC} = 12V)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
STATIC CHARACTERISTICS							
Supply Current	I_{13}			12	17	22	mA
Amplifier Input Reference	V_6				1.45		V
Detector Input Reference	V_2				3.65		V
Amplifier High Output Level	V_{10}			1.25	1.45	1.65	V
Amplifier Low Output Level	V_9			0.125	0.145	0.20	V
Detector Output Level	V_1			4.3	5.0	5.7	V
De-emphasis Resistance	R_d			7.2	8.8	10.8	kΩ
DYNAMIC CHARACTERISTICS f_0 = 4.5 MH ΔF = ±25 kHz, Peak Separation = 15.0 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A_{IF}	1	$V_{IN} \leq 0.3$ mVrms	55	58		dB
Amplifier Output Voltage	$V_{10(IF)}$	1	V_{IN} = 10 mV	1.25	1.45		$V_{p\text{-}p}$
Input Limiting Threshold	$V_{IN(LIM)}$	2	FM = 400 Hz		400	800	μVrms
Recovered Audio Output	$V_{O(af)}$	2	V_{IN} = 60 mV, FM = 400 Hz	0.5	0.6		Vrms
Output Distortion	T_{HD}	2	100% FM Modulation		1.5		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V_{IN} = 10 mV	40	46		dB
DYNAMIC CHARACTERISTICS f_0 = 10.7 MHz, ΔF = ±75 kHz, Peak Separation = 1 MHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A_{IF}	1	$V_{IN} \leq 0.3$ mVrms		53		dB
Amplifier Output Voltage	$V_{10(IF)}$	1	V_{IN} = 10 mV		1.45		$V_{p\text{-}p}$
Input Limiting Threshold	$V_{IN(LIM)}$	2	FM = 400 Hz		300		μVrms
Recovered Audio Output	$V_{O(af)}$	2	V_{IN} = 60 mV, FM = 400 Hz		0.3		Vrms
Output Distortion	T_{HD}	2	100% FM Modulation		0.3		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V_{IN} = 10 mV		40		dB

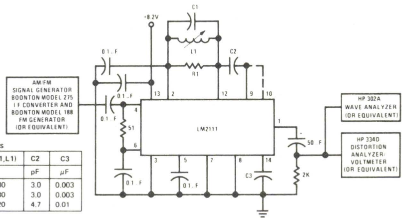
test circuit



TEST CIRCUIT 1

COMPONENT VALUES

f	L1	C1	R1	Q(R1,L1)	C2	C3
MHz	μH	pF	kΩ		pF	μF
4.5	14	120	20	30	3.0	0.003
5.5	8.0	100	20	30	3.0	0.003
10.7	2.0	120	3.9	20	4.7	0.01



TEST CIRCUIT 2

Consumer Circuits

LM2113 FM detector and limiter

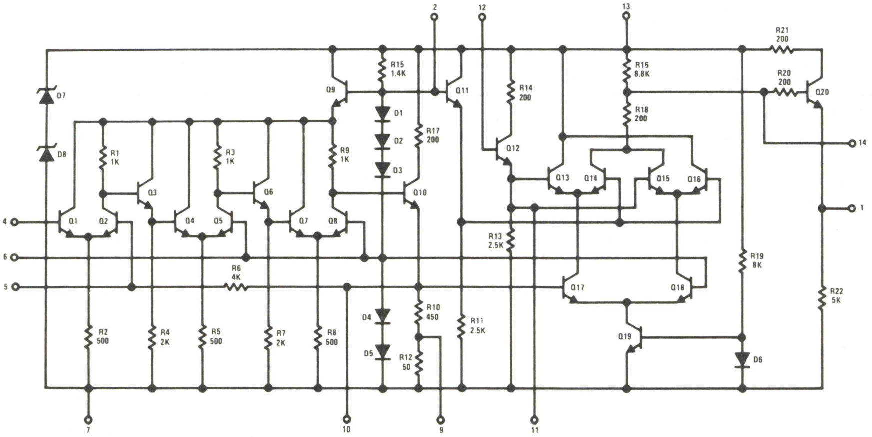
general description

The LM2113 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector.

features

- A direct replacement for ULN 2113A
- Simple detector alignment: one coil or ceramic filter
- Sensitivity: 3 dB limiting voltage 300 μV typ.
- Low harmonic distortion
- High IF voltage gain
- Nominal 8V supply

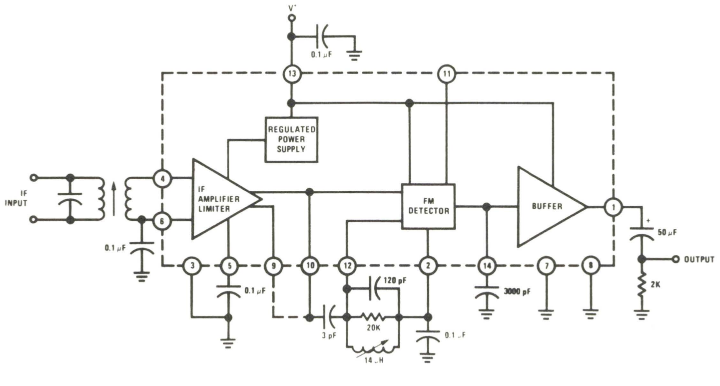
schematic diagram



Order Number LM2113N
See Package 22

Order Number LM2113N-01
See Package 24

block diagram



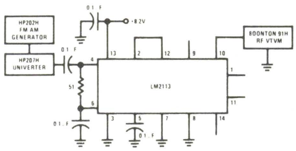
absolute maximum ratings

Supply Voltage	14V
Input Signal Voltage (Pin 4)	3.5V
Power Dissipation	
$T_A = 25°C$ or less	850 mW
$T_A = 25°C$ or more	Derate Linearly 6.67 mW/°C
Operating Temperature Range	0°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($T_A = 25°C$, $V_{CC} = 8.2V$)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS MIN	TYP	MAX	UNITS
STATIC CHARACTERISTICS							
Supply Current	I_{13}			11	16	22	mA
Amplifier Input Reference	V_6				1.45		V
Detector Input Reference	V_2				3.65		V
Amplifier High Output Level	V_{10}			1.25	1.45	1.65	V
Amplifier Low Output Level	V_9			0.125	0.145	0.20	V
Detector Output Level	V_1			3.0	3.8	4.5	V
De-emphasis Resistance	R_d			7.2	8.8	10.8	kΩ
DYNAMIC CHARACTERISTICS $f_0 = 4.5$ MH, $\Delta f = \pm 25$ kHz, Peak Separation = 150 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A_{IF}	1	$V_{IN} \leq 0.3$ mVrms		58		dB
Amplifier Output Voltage	$V_{10(IF)}$	1	$V_{IN} = 10$ mV		1.45		V_{p-p}
Input Limiting Threshold	$V_{IN(LIM)}$	2	FM = 400 Hz		300		μVrms
Recovered Audio Output	$V_{0(af)}$	2	$V_{IN} = 60$ mV, FM = 400 Hz		0.5		Vrms
Output Distortion	T_{HD}	2	100% FM Modulation		1.5		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, $V_{IN} = 10$ mV		46		dB
DYNAMIC CHARACTERISTICS $f_0 = 10.7$ MHz, $\Delta f = \pm 75$ kHz, Peak Separation = 550 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A_{IF}	1	$V_{IN} \leq 0.3$ mVrms		53		dB
Amplifier Output Voltage	$V_{10(IF)}$	1	$V_{IN} = 10$ mV		1.45		V_{p-p}
Input Limiting Threshold	$V_{IN(LIM)}$	2	FM = 400 Hz	230	300	500	μV
Recovered Audio Output	$V_{0(af)}$	2	$V_{IN} = 60$ mV, FM = 400 Hz	0.3	0.4	0.5	Vrms
Output Distortion	T_{HD}	2	100% FM Modulation		1.0		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, $V_{IN} = 10$ mV		40		dB

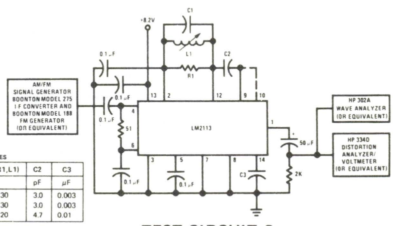
test circuits



TEST CIRCUIT 1

COMPONENT VALUES

f	L1	C1	R1	Q(R1,L1)	C2	C3
MHz	μH	pF	kΩ		pF	μF
4.5	14	120	20	30	3.0	0.003
5.5	8.0	100	20	30	3.0	0.003
10.7	2.0	120	3.9	20	4.7	0.01



TEST CIRCUIT 2

5

Consumer Circuits

LM3011 wide band amplifier

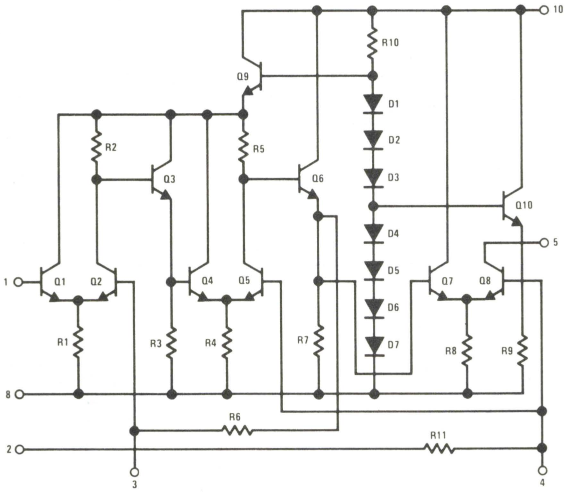
general description

The LM3011 is a monolithic wide band amplifier circuit that requires a minimum of external components for operation. It includes three stages of limiting.

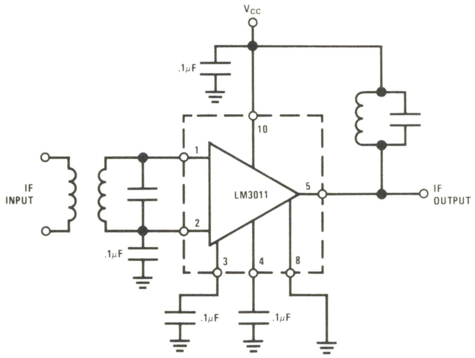
features

- A direct replacement for CA3011
- High amplifier gain
- Excellent limiting characteristics
- Wide frequency capability

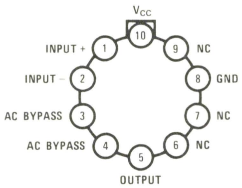
schematic diagram



block diagram



connection diagram



Order Number LM3011H
See Package 12

absolute maximum ratings

Supply Voltage	15V	Operating Temperature Range	−55°C to +125°C
Input Signal (Pin 1)	±3V	Storage Temperature Range	−65°C to +150°C
Power Dissipation	300 mW	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
STATIC CHARACTERISTICS					
Total Device Dissipation (P_T)	V_{CC} = 6V (Figure 1)	60	90	133	mW
Total Device Dissipation (P_T)	V_{CC} = 7.5V (Figure 1)	95	120	187	mW
DYNAMIC CHARACTERISTICS V_{CC} = 7.5V, F = 4.5 MHz, unless otherwise noted					
Voltage Gain (A)	V_{CC} = 6V, f = 1 MHz (Figure 2)	60	66		dB
Voltage Gain (A)	V_{CC} = 7.5V, f = 1 MHz (Figure 2)	65	70		dB
Voltage Gain (A)	V_{CC} = 7.5V, f = 10.7 MHz (Figure 2)	55	61		dB
Parallel Input Resistance (R_{IN})			3		kΩ
Parallel Input Capacitance (C_{IN})			7		pF
Parallel Output Resistance (R_{OUT})			31.5		kΩ
Parallel Output Capacitance (C_{OUT})			4.2		pF
Noise Figure (NF)			8.7		dB
Input Limiting Voltage ($V_{IN(Lim)}$)	(−3 dB) (Figure 2)		300	400	μV

test circuits

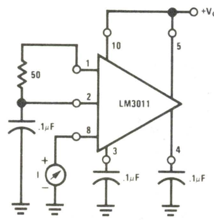


FIGURE 1

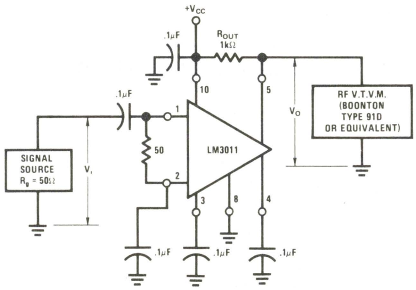


FIGURE 2

Consumer Circuits

LM3028A/LM3028B/LM3053 differential rf/if amplifier

general description

The LM3028A/LM3028B/LM3053 is a monolithic RF/IF amplifier intended for emitter-coupled (differential) or cascode amplifier operation from DC to 120 MHz in industrial and communications equipment. The LM3028A/LM3028B and LM3053 are plug-in replacements for the CA3028A/CA3028B and CA3053 respectively. The LM3028B is similar to the LM3028A but has premium performance with tighter limits in offset voltage and current, bias current and voltage gain. The LM3053 is similar to the LM3028A/LM3028B but is recommended for IF amplifier operation with less critical DC parameters.

features

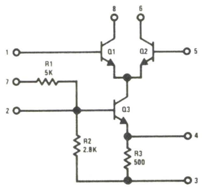
- Controlled for input offset voltage, input offset current, and input bias current*
- Balanced differential amplifier configuration with controlled constant-current source to provide unexcelled versatility
- Single- and dual-ended operation
- Operation from DC to 120 MHz*
- Balanced-AGC capability*
- Wide operating-current range.

*Does not apply to the LM3053.

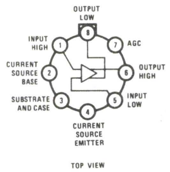
applications

- RF and IF linear amplifiers, both differential and cascode
- Mixers
- Oscillators
- Converters in commercial FM
- DC, audio and sense amplifiers
- Limiting IF amplifiers
- Hybrid building block
- Emitter coupled switches

schematic and connection diagrams

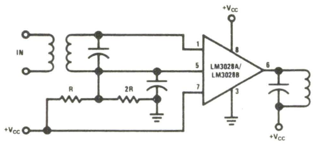


Metal Can Package

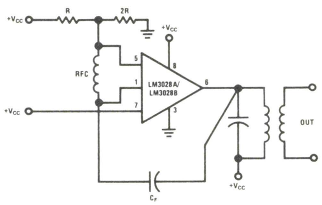


Order Number LM3028AH or LM3028BH or LM3053H
See Package 11

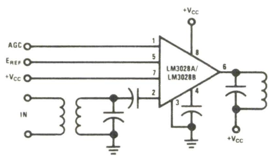
typical applications



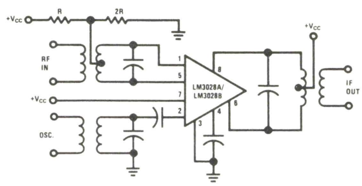
A Balanced Differential Amplifier with a Controlled Constant-Current-Source Drive and AGC Capability



Oscillator



A Cascode Amplifier with a Constant-Impedance AGC Capability



Mixer

absolute maximum ratings

	LM3028A/ LM3028B	LM3053
Supply Operating Voltage	±15V	±12V
Differential Input Voltage	±5V	±5V
Voltage Between 1 & 8	0V to +20V	0V to +15V
Voltage Between 5 & 6	0V to +20V	0V to +15V
Voltage Between 2 & 3	+5V to −11V	+5V to −11V
Voltage Between 2 & 4	+5V to −1V	+5V to −1V

Storage Temperature	−65°C to 200°C
Operating Temperature	−55°C to 125°C
Power Dissipation @ 25°C	450 mW
Derate 5 mW/°C Above 85°C	
Lead Temperature (Soldering, 10 sec)	300°C

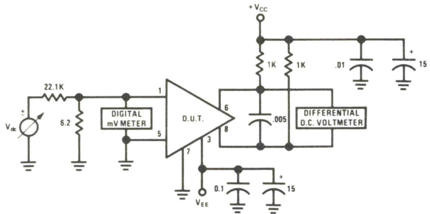
dc electrical characteristics

	SYMBOL	TEST CIRCUIT	V_{CC}	V_{EE}	LM3028A MIN	LM3028A TYP	LM3028A MAX	LM3028B MIN	LM3028B TYP	LM3028B MAX	LM3053 MIN	LM3053 TYP	LM3053 MAX	UNITS
Input Offset Voltage	V_{OS}	A	6	−6			5.0		0.4	2.0				mV
			12	−12			5.0		0.4	2.0				mV
Input Offset Current	I_{OS}	B	6	−6			5.0		0.15	2.0				μA
			12	−12			5.0		0.25	2.0				μA
Input Bias Current	I_{BIAS}	B	6	−6		7.5	50		7.5	40				μA
		B	12	−12		17	106		17	80				μA
		C	9	–								13	85	μA
		C	12	–								18	125	μA
Output Quiescent Operating Current	I_Q	B	6	−6	0.9	1.25	2.0	1.1	1.25	1.5				
		B	12	−12	2.3	3.15	5.0	2.5	3.15	4.0				
		C	9	–							1.2	2.2	3.5	mA
		C	12	–							2.3	3.15	5.0	mA
AGC Bias Current into Terminal 7	I_{AGC}	D	12	V_{AGC}=9V		1.1			1.1					mA
		D	12	V_{AGC}=12V		1.5			1.5					mA
			9									1.05		mA
			12									1.45		mA
Input Current into Terminal 7	I_7	B	6	−6	0.5	0.7	1.1	0.5	0.7	1.1				mA
		B	12	−12	1.0	1.5	2.2	1.0	1.5	2.2				mA
Power Dissipation	P_D	B	6	−6	24	35	54	24	35	42				mW
		B	12	−12	120	170	260	120	170	220				mW
		C	9	–								48	80	mW
		C	12	–								91	150	mW

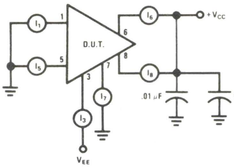
ac electrical characteristics

	SYMBOL	TEST CIRCUIT	V_{CC}	V_{EE}	LM3028A MIN	LM3028A TYP	LM3028A MAX	LM3028B MIN	LM3028B TYP	LM3028B MAX	LM3053 MIN	LM3053 TYP	LM3053 MAX	UNITS
100 MHz Power Gain	A_P	E(Cascode)	9	–	17	22		17	22					dB
		F(Diff.)	9	–	14.5	18.5		14.5	18.5					dB
10.7 MHz Power Gain	A_P	E(Cascode)	9	–	36	42		36	42					dB
		F(Diff.)	9	–	29	33.5		29	33.5					dB
100 MHz Noise Figure	NF	E(Cascode)	9	–		6.7	9.0		6.7	9.0				dB
		F(Diff.)	9	–		5.9	9.0		5.9	9.0				dB
Input Admittance at 10.7 MHz	y_{11}	Cascode	+9	–		0.5+j1.3			0.5+j1.3			0.5+j1.3		mmho
		Diff.	+9	–		0.4+j0.58			0.4+j0.58			0.4+j0.58		mmho
Reverse Transadmittance at 10.7 MHz	y_{12}	Cascode	+9	–		0.2+j0			0.2+j0			0.2+j0		μmho
		Diff.	+9	–		10+j0.2			10+j0.2			10+j0.2		μmho
Forward Transadmittance at 10.7 MHz	y_{21}	Cascode	+9	–		95–j27			95–j27			95–j27		mmho
		Diff.	+9	–		−32+j.5			−32+j.5			−32+j.5		mmho
Output Admittance at 10.7 MHz	y_{22}	Cascode	+9	–		0+j100			0+j100			0+j100		μmho
		Diff.	+9	–		20+j160			20+j160			20+j160		μmho
Output Power (Untuned) at 10.7 MHz	P_O	G	+9	–		5.7			5.7			5.7		μW
AGC Range at 10.7 MHz		F	+9	–		76			76			76		dB
Voltage Gain at 10.7 MHz	A_V	H(Cascode)	+9	–		40			40			40		dB
		I(Diff.)	+9	–		30			30			30		dB
Differential 1 kHz Voltage Gain	A_{VD}	J	6	−6				35	38	42				dB
		J	12	−12				40	42.5	45				dB
Maximum Peak to Peak Output Voltage at 1 kHz	$V_{OUT,\ pp}^{MAX}$	J R_L=2k	6	−6				8	11					V_{p-p}
		J R_L=1.6k	12	−12				16	22					V_{p-p}
3 dB Bandwidth	BW	J R_L=2k	6	−6					11.2					MHz
		J R_L=1.6k	12	−12					12.7					MHz
Common-Mode Input Voltage Range	V_{CM}	K	6	−6				−2.5	−3.2 to +4.5	4				V
		K	12	−12				−5	−7 to +9	7				V
Common-Mode Rejection Ratio	CMRR	K	6	−6				60	110					dB
		K	12	−12				60	90					dB
Peak to Peak Output Current V_{IN} = 400 mV at 10.7 MHz	I_{p-p}	Diff.	9	–	2	4.7	7	2.5	4.7	6	2	4.7	7	mA
		Diff.	12	–	3.5	6.5	10	4.5	6.5	8	3.5	6.5	10	mA

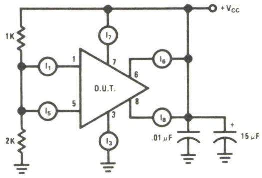
test circuits



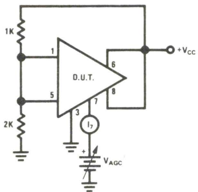
Test Circuit A: VOS LM3028A & LM3028B



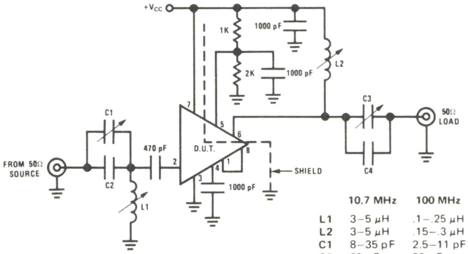
Test Circuit B: I_{OS}, I_{BIAS}, P_D, I_Q & I_7 for LM3028A & LM3028B



Test Circuit C: I_{BIAS}, P_D, I_Q for LM3053

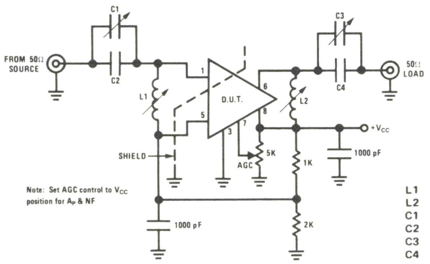


Test Circuit D: I_{AGC} vs V_{AGC} and I_7 for LM3028A & LM3028B



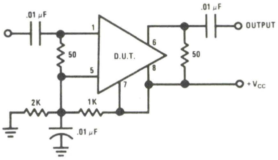
	10.7 MHz	100 MHz
L1	3–5 μH	.1–.25 μH
L2	3–5 μH	.15–.3 μH
C1	8–35 pF	2.5–11 pF
C2	39 pF	20 pF
C3	8–35 pF	2.5–11 pF
C4	36 pF	–

Test Circuit E: Cascode Ap & NF 10.7 MHz & 100 MHz

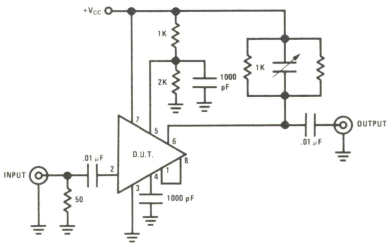


	10.7 MHz	100 MHz
L1	3–6 μH	.2–.5 μH
L2	3–6 μH	.2–.5 μH
C1	8–35 pF	2.5–11 pF
C2	39 pF	–
C3	8–35 pF	2.5–11 pF
C4	36 pF	–

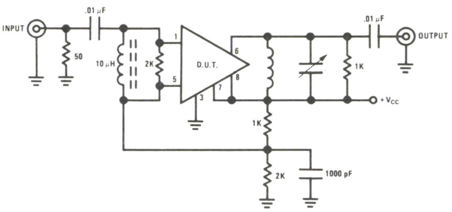
Test Circuit F: Differential A_P, NF and AGC Range, 10.7 MHz & 100 MHz



Test Circuit G: P_O (Untuned) for LM3028A & LM3028B

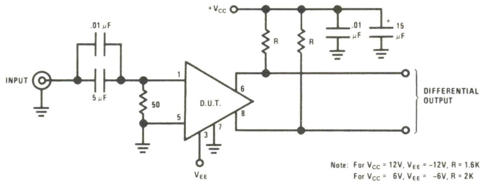


Test Circuit H: Cascode A_V and Transfer Function, 10.7 MHz

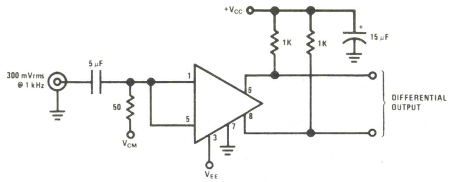


Test Circuit I: Differential Mode A_V and Transfer Function, 10.7 MHz

test circuits (con't)



Test Circuit J: A_V, V_{OUT}, MAX, p/p B.W. for LM3028B



Test Circuit K: CMRR and V_{CM} Range for LM3028B

Consumer Circuits

LM3064 television automatic fine tuning

general description

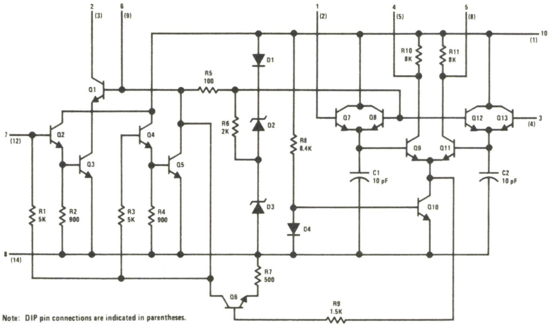
The LM3064 is a monolithic integrated circuit designed primarily for AFT (automatic fine tuning) applications. It includes a zener regulated power supply, IF amp, differential peak detector, and an AGC circuit.

The LM3064 is supplied in both the formed and straight lead TO-5 and 14 lead dual-in-line package.

features

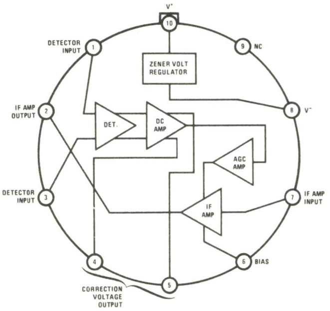
- Primarily intended for AFT applications
- High gain input amp (18 mV for rated output)
- Differential output correction voltage
- Wide operating temperature −40°C to +85°C
- Formed leads available for easy PC board design

schematic and connection diagrams



Note: DIP pin connections are indicated in parentheses.

Metal Can Package

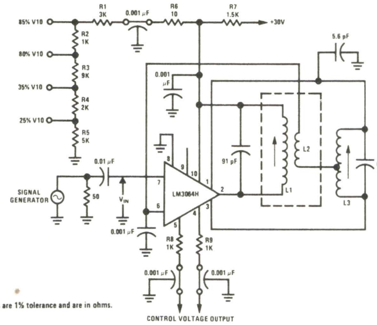


TOP VIEW

Order Number LM3064H
See Package 14&29

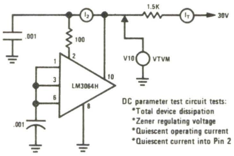
test circuits

Test Circuit 1
Correction Voltage Test Circuit



All resistors are 1% tolerance and are in ohms.

Test Circuit 2
DC Parameter Test Circuit



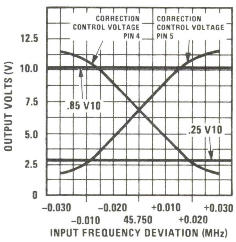
absolute maximum ratings

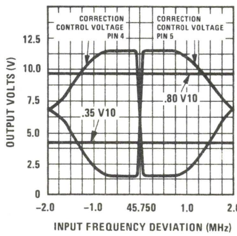
Power Dissipation		Operating Temperature Range	−40°C to +85°C
T_A = 25°C or Less	700 mW	Storage Temperature Range	−65°C to +150°C
T_A = 25°C or More	Derate Linearly 5.6 mW/°C for TO-5 Derate Linearly 10 mW/°C for DIP	Power Supply Current	50 mA

electrical characteristics (T_A = 25°C)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS MIN	LIMITS MAX	UNITS
STATIC						
Device Dissipation	P_T	2	V_{CC} = 30V; R_S = 1.5k	130	150	mW
Current Drain	I_T	2	V_{10} = 10.5V	4.0	9.5	mA
Zener Regulating Voltage	V_{10}	2	V_{CC} = 30V; R_S = 1.5k	10.9	12.8	V
Quiescent Current into Pin 2	I_2	2	V_{CC} = 30V; R_S = 1.5k	1	4	mA
Quiescent Voltage at Pin 4	V_4	1	V_{CC} = 30V; R_S = 1.5k	5.0	8.0	V
Quiescent Voltage at Pin 5	V_5	1	V_{CC} = 30V; R_S = 1.5k	5.0	8.0	V
Output Offset Voltage between Pins 4 & 5	V_4–V_5	1	V_{CC} = 30V; R_S = 1.5k	−1.0	+1.0	V
DYNAMIC – Output Voltage vs Frequency Deviation AFT						
				Correction Voltage as Shown Below		
Correction Control Voltage at Pin 4			V_{CC} = 30V; R_S = 1.5k V_i = 18 mV	% of V_{10}	% of V_{10}	
	V_4	1	f = 45.75 – .03 MHz	85		V
	V_4	1	f = 45.75 + .03 MHz		25	V
	V_4	1	f = 45.75 – .9 MHz	80		V
	V_4	1	f = 45.75 + .9 MHz		35	V
	V_4	1	f = 45.75 – 1.5 MHz		80	V
	V_4	1	f = 45.75 + 1.5 MHz	35		V
Correction Control Voltage at Pin 5 See Curves	V_5	1	f = 45.75 – .03 MHz		25	V
	V_5	1	f = 45.75 + .03 MHz	85		V
	V_5	1	f = 45.75 – .9 MHz		35	V
	V_5	1	f = 45.75 + .9 MHz	80		V
	V_5	1	f = 45.75 – 1.5 MHz	35		V
	V_5	1	f = 45.75 + 1.5 MHz		80	V

correction control voltage





coil winding data

COIL DATA FOR DISCRIMINATOR WINDINGS

L_1 – Discriminator Primary: 3-1/6 turns; No. 20 Enamel-covered wire–close-wound, at bottom of coil form. Inductance of L_1 = 0.165 μH; Q_o = 120 at f_o = 45.75 MHz.

Start winding at Terminal No. 6; finish at Terminal No. 1. See Notes below.

L_2 – Tertiary Windings: 2-1/6 turns; No. 20 Enamel-covered wire–close-wound over bottom end of L_1. Start winding at Terminal No. 3; finish at Terminal No. 4. See Notes below.

L_3 – Discriminator Secondary: 3-1/2 turns; center-tapped, space wound at bottom of coil form. Inductance of L_3 = 0.180 μH; Q_o = 150 at f_o = 45.75 MHz.

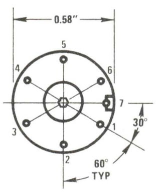
Start winding at Terminal No. 2; finish at Terminal No. 5, connect center tap to Terminal No. 7. See Notes.

Note 1: Coil Forms; Cylindrical; ~0.30" Dia. max.

Note 2: Tuning Core: 0.250" Dia. x 0.37" Lngth. Material: Carbinal J or equivalent.

Note 3: Coil Form Base: See drawing below.

Note 4: End of coil nearest terminal board to be designated the winding start end.



L_1 is aligned for symmetrical bandwidth on either side of 45.750 MHz

L_2 tertiary winding wound on L_1 coil form

L_3 is aligned for zero differential output between terminals 4 and 5 at f_o = 45.750 MHz

Consumer Circuits

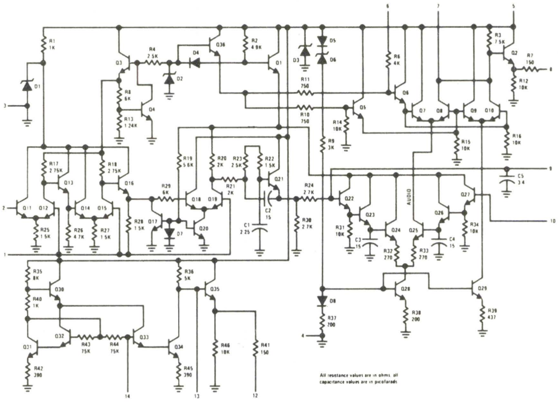
LM3065 television sound system

general description

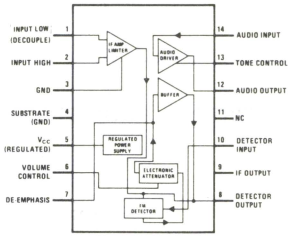
The LM3065 is a monolithic integrated circuit television sound system that requires a minimum of external components for operation. It includes three stages of IF limiting, an FM detector, an electronic attenuator or volume control, an audio amplifier-driver, and a temperature stable regulated power supply. Volume control is accomplished by varying bias levels of the electronic attenuator with a potentiometer between pin 6 and ground. Because no audio signal is present in this control, hum and noise pickup are easily filtered. Unshielded wire may be used for volume control. Features include:

- Electronic attenuator: replaces conventional ac volume control
- Volume reduction range: >60 dB
- Sensitivity: 3 dB limiting voltage—200 μV typically
- High stability
- Low harmonic distortion
- Audio drive capability: 6 mA p-p
- Undistorted audio output voltage: 7V p-p
- Differential peak detector
- Simple detector alignment: one coil
- Internal zener diode regulator
- Excellent AM rejection—50 dB typ. @ 4.5 MHz

schematic and connection diagrams



Dual-In-Line Package

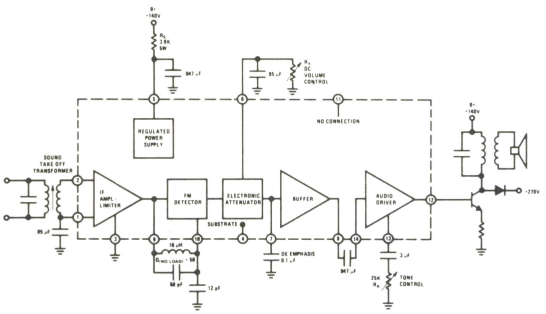


TOP VIEW

Order Number LM3065N
See Package 22

Order Number LM3065N-01
See Package 24

block diagram



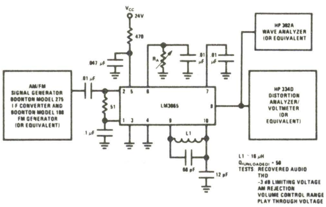
absolute maximum ratings

Input Signal Voltage (Between Pin 1 and 2)	±3V	Power Dissipation	
Power Supply Current (Pin 5)	75 mA	T_A = 25°C or less	850 mW
		T_A = 25°C or more	Derate Linearly 6.67 mW/°C
		Operating Temperature Range	−40°C to +85°C
		Storage Temperature Range	−65°C to +150°C

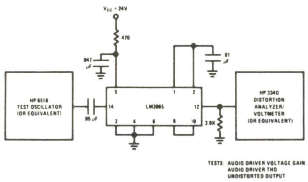
electrical characteristics

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS MIN	TYP	MAX	UNITS
Static Characteristics							
Zener Regulating Voltage	V_5			10.3	11.5	12.2	V
Ouiescent Supply Current	I_5				28		mA
Voltage @ Pin 12	V_{12}			4.0	5.2	5.8	V
Current into Terminal 5	I_5		V_5 = 9V	10.0	12.3	24	mA
Dynamic Characteristics							
IF Amplifier/Detector							
Input Limiting Voltage (−3 dB point)	V_{IN} (lim)	1	fo = 4.5 MHz fm: 400 Hz @ ±25 kHz		200	400	μV
Recovered Audio	V_O (af)	1	fo = 4.5 MHz, V_{IN} = 100 mV fm: 400 Hz @ ±25 kHz	500	750		mV rms
AM Rejection	AMR	1	fo = 4.5 MHz, fm: 400 Hz @ ±25 kHz AM: 1 kHz @ 30%	40	50		dB
Total Harmonic Distortion	THD	1	fo = 4.5 MHz, V_{IN} = 100 mV fm: 400 Hz @ ±25 kHz		.9	2	%
Attenuator							
Volume Reduction Range			fo = 4.5 MHz fm: 400 Hz @ ±25 kHz R_A = 0 for max-volume; R_A = ∞ for minimum volume	60			dB
Audio Driver							
Voltage Gain	Av(af)	2	V_{IN} = 100 mV @ 400 cps	17.5	20		dB
Total Harmonic Distortion	THD	2	V_O = 2V rms @ 400 cps		1.5		%
Undistorted Output Voltage		2	THD = 5% @ 400 cps	2	2.5		V rms

test circuits



TEST CIRCUIT 1



TEST CIRCUIT 2

Consumer Circuits

LM3066 chroma signal processor

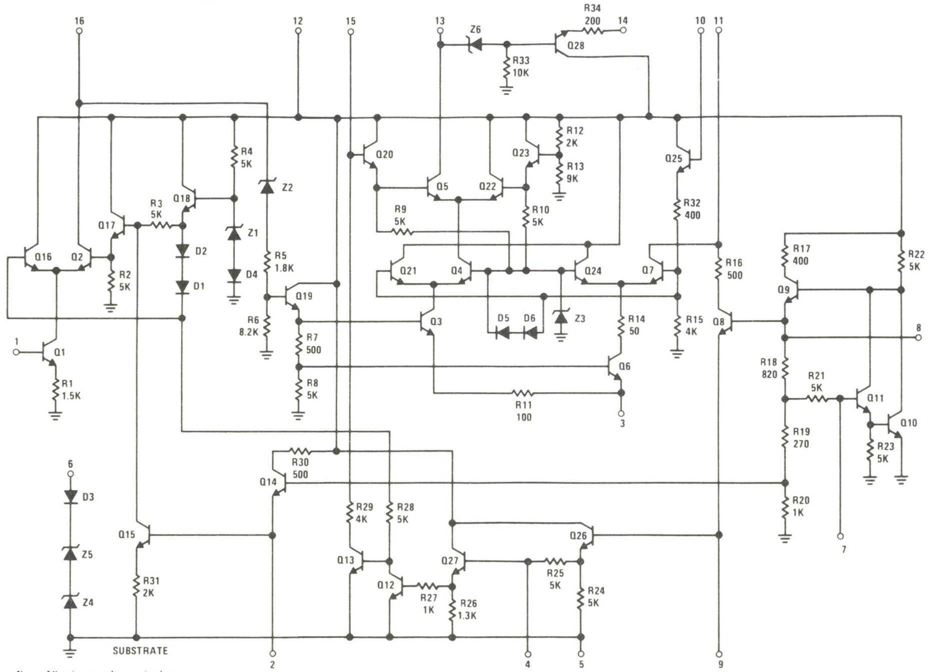
general description

The LM3066 is a monolithic integrated circuit designed for color signal processing in color television receivers. It includes gain controlled chroma and bandpass amplifiers, chroma output stage, gated burst amplifier, 3.58 MHz injection-locked oscillator, automatic chroma control (ACC) detector-amplifier, killer detector-amplifier, and a zener-regulated voltage reference. The input chroma signal is applied to the chroma amplifier which is controlled by the ACC detector-amplifier maintaining a constant chroma level at terminal 16. The chroma amplifier feeds the chroma signal in parallel to the bandpass and burst amplifiers. The bandpass amplifier is gain controlled by the DC chroma gain control and is also controlled by the killer detector-amplifier. The horizontal keying pulse gates the burst signal from the bandpass amplifier to the burst amplifier which then injects the burst signal into the 3.58 oscillator. The ACC and killer detectors sense the oscillator amplitude. Thresholds are set independently at terminals 9 and 4. The LM3066 and the LM3067 Chroma Demodulator constitute a complete chroma system for color television receivers.

features

- Complete color sync circuitry
- Blanked chroma amplifier
- Chroma bandpass amplifier
- Low output impedance chroma driver
- Color killer
- Automatic color control
- DC chroma gain control
- Zener regulated voltage reference
- Aligned independently
- Short circuit protection

schematic diagram



Note: All resistance values are in ohms.

Order Number LM3066N
See Package 23

Order Number LM3066N-01
See Package 25

absolute maximum ratings

Power Dissipation	
$T_A = 70°C$ or less	600 mW
Above 70°C	derate linearly 7.7 mW/°C
Ambient Temperature Range	
Operating	−40 to +85°C
Storage	−65 to +150°C
Power Supply Voltage (Pin 12)	+12V
Power Supply Current (Pin 12)	50 mA

electrical characteristics ($T_A = 25°C$ and $V^+ = 11.2V$)

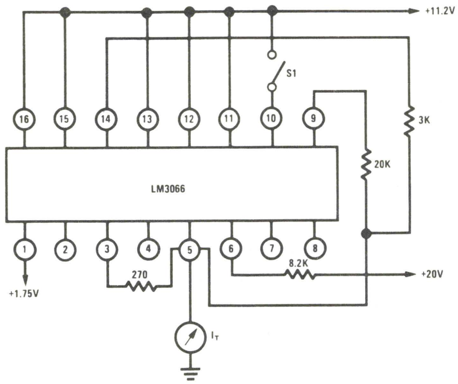
PARAMETERS	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
STATIC CHARACTERISTICS (Test Circuit 1)					
ACC Reference (V_2)			.5		V
Burst-Chroma Bias (V_3)			2.9		V
Killer Reference (V_4)			1.0		V
Zener Reg. Reference (V_6)		10.6	11.9	12.6	V
Oscillator Input (V_7)			1.3		V
Oscillator Output (V_8)			2.3		V
Balance (ACC Control) (V_9)			1.65		V
Chroma Output (V_{14})			4.6		V
Burst-Sperator Output (I_{11})	S1 Closed		6.5		mA
Bandpass Amplifier Output (I_{13})			4.8		mA
Chroma Amplifier Output (I_{16})			1.27		mA
Quiescent Supply Current (I_5)		14	24	33	mA
DYNAMIC CHARACTERISTICS (Test Circuit 2)					
Oscillator Output (V_8)	$V_1 = 0\ V_{p-p}$	0.8	1.05		V_{p-p}
	$V_1 = 1.25\ V_{p-p}$		2.5	3.5	V_{p-p}
Chroma Output (V_{14})					
100%	$V_1 = 1.25\ V_{p-p}$	0.5	1.0		V_{p-p}
Killed	$V_1 = .025\ V_{p-p}$			.02	V_{p-p}
ACC Detector Output (V_2)	$V_1 = 1.25\ V_{p-p}$		0.9		V
Small Signal Input Resistance (r_i)			50		kΩ
Small Signal Input Capacitance (C_i)			2.4		pF
Small Signal Output Impedance (r_o)			250		Ω

DYNAMIC CHARACTERISTICS TEST PROCEDURE

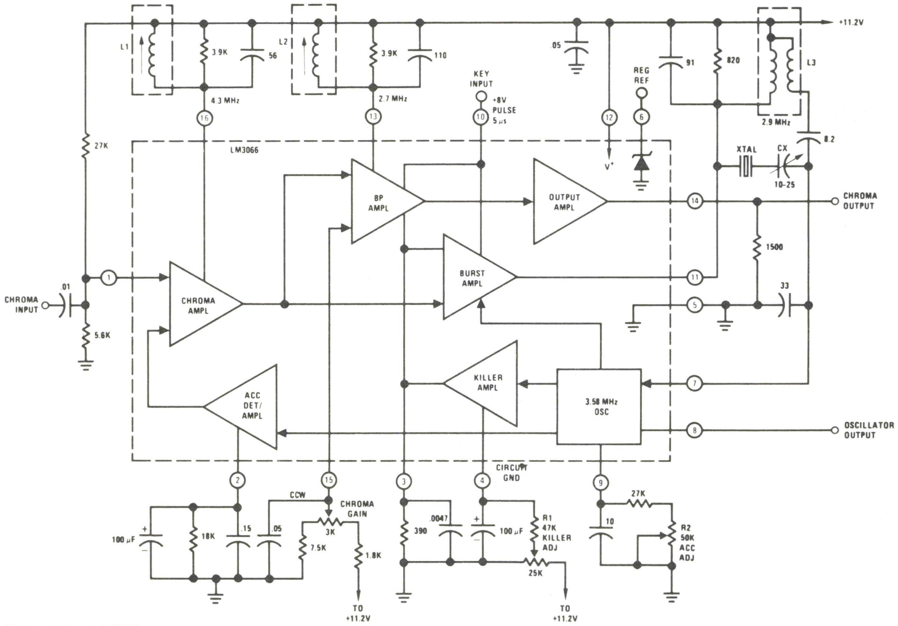
Note 1: $V_1 = 0\ V_{p-p}$
(A) Adjust $V_2 = +0.65V$
(B) Adjust $V_4 = +1.2V$
(C) Adjust C_X so $f_{OSC} = 3.579545$ MHz.

Note 2: Chroma input test signal (V_1) is a 52 μs line at subcarrier frequency and 10 cycles of burst at 46.5% of line amplitude.

test circuits



TEST CIRCUIT 1



All resistance values are in OHMS
Unless otherwise indicated, all capacitance values less than 1.0 are in microfarads, 1.0 or greater are in picofarads
All coils have a $Q_{OU} > 30$

TEST CIRCUIT 2

Consumer Circuits

LM3067 chroma demodulator

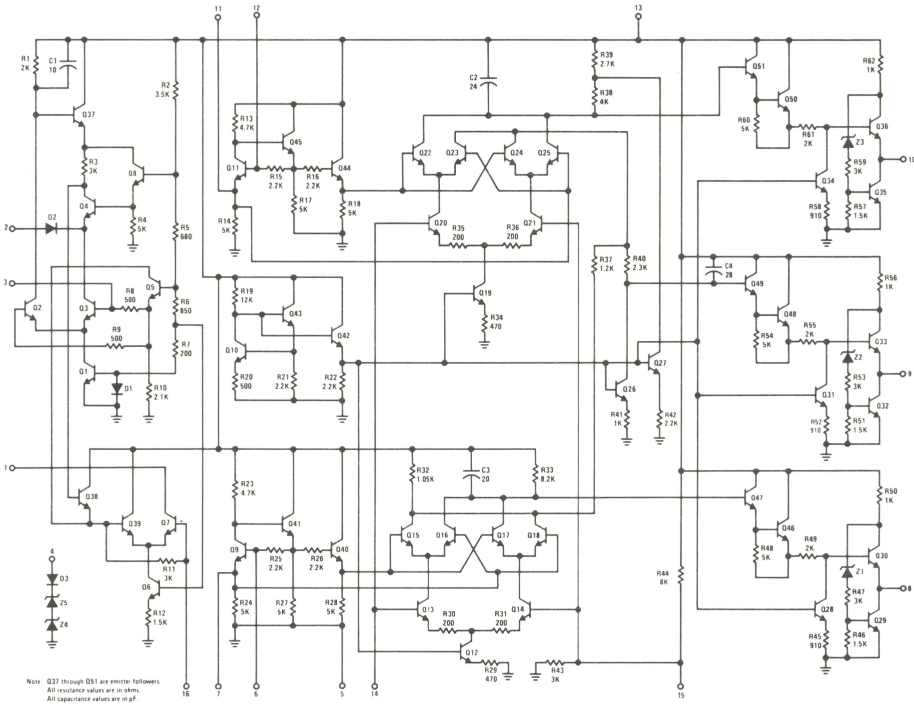
general description

The LM3067 is a monolithic integrated circuit designed primarily for color signal demodulation in color television receivers. A DC tint control is also included. The reference subcarrier and chroma signals are applied and the three demodulated R–Y, G–Y, B–Y color difference signals are delivered with close DC balance and proper amplitude ratios. The tint control achieves a 100°+ phase adjustment by means of a customer-operated DC control. A limiting amplifier and phase shift network provide constant amplitude carriers phase shifted 76° which then feed demodulator drive amplifiers. The demodulators consist of two sets of balanced detectors which receive the reference subcarrier and chroma signal. The chroma signal is then demodulated, matrixed, and DC shifted in voltage. The LM3067 and LM3066 Chroma Signal Processor constitute a complete chroma system for color television receivers.

features

- Balanced chroma demodulators
- DC tint control
- Color difference matrix
- Low output impedance drivers for direct coupling
- Reference subcarrier limiter
- Zener regulated voltage reference
- Internal RF filtering of demodulation components

schematic diagram



Order Number LM3067N
See Package 23

Order Number LM3067N-01
See Package 25

absolute maximum ratings

Power Dissipation	
T_A = 70°C or less	600 mW
Above 70°C	derate linearly 7.7 mW/°C
Ambient Temperature Range	
Operating	−40 to +85°C
Storage	−65 to +150°C
Power Supply Voltage (Pin 13)	+12V
Power Supply Current (Pin 13)	50 mA

electrical characteristics (T_A = 25°C and V^+ = 11.2V)

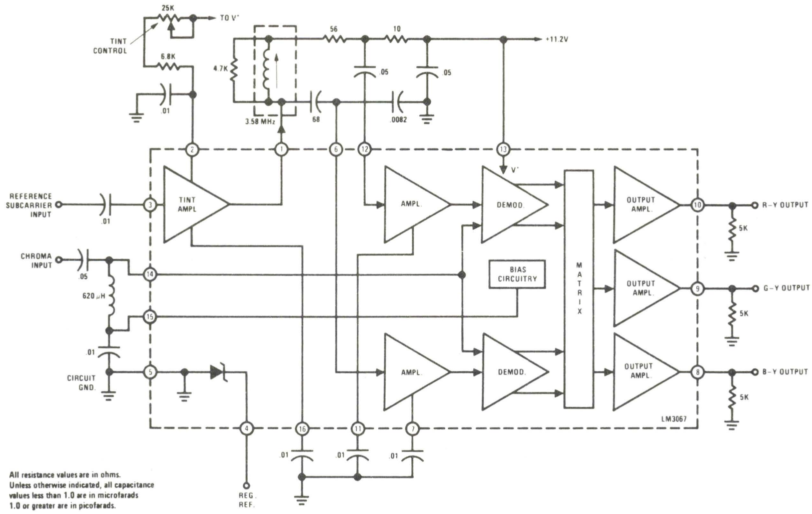
PARAMETERS	CHARACTERISTICS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
Static Characteristics (Test Circuit 1)					
Voltage Inputs					
Tint Control Input (V_2)	I_2 = 0.25 mA		3.5		
Reference Subcarrier (V_3)			2.1		
Zener Regulator Ref. (V_4)		10.6	11.9	12.6	V
B−Y, R−Y Oscillator Ref. Inputs (V_6,V_{12})			5.7		
Balance (B−Y, R−Y) (V_7,V_{11})			5.0		
B−Y, G−Y, R−Y Outputs ($V_{8,9,10}$)		4.2	5.0	5.8	
Difference Outputs (Note 1), (ΔV_8,ΔV_9,ΔV_{10})		−0.3		0.3	
Chroma Inputs (V_{14},V_{15})			3.0		
Tint Amplifier Balance (V_{16})			4.7		
Input Currents					
Tint Amplifier Output (min.) (I_1(min.))	V_{16} = 8V	0.16	0.37		mA
Total Supply (I_1 + I_{13})		15	24	33	
Dynamic Characteristics (Test Circuit 2)					
Tint Amplifier Output					
Sensitivity (V_1)	V_3 = 7 mVRMS	160	250		mVRMS
Limiting Knee (V_1)	V_3 = 35 mVRMS		300		
Limiting (V_1)	V_3 = 350 mVRMS			380	
Tint Amplifier Phase Ref. (Note 2) (ϕ_6)	V_3 = 70 mVRMS	185	220	235	degrees
Tint Amplifier Phase Ref. (Note 3) ($\Delta\phi_6$)	V_3 = 70 mVRMS	90	105		degrees
Demodulated Chroma Outputs					
R−Y (V_{10})	V_3 = 70 mVRMS	0.15	0.25		VRMS
Ratio of G−Y to R−Y (V_9/V_{10})	V_{14} = 35 mVRMS	0.28	0.36	0.44	
Ratio of B−Y to R−Y (V_8/V_{10})		1.0	1.2	1.4	
Color Difference Output					
BW at 3.3 dB ($BW_{Diff.}$)		450	550		kHz
Color Difference Outputs (max. input signals):					
R−Y (V_{10})			3.0		
G−Y (V_9)	V_3 = 70 mVRMS		1.1		$V_{p\text{-}p}$
B−Y (V_8)	V_{14} 212 mVRMS		3.6		
Small Signal Input Resistance					
Terminal Number 3 (r_i)			550		Ω
Terminal Numbers 6 and 12 (r_i)			22		
Small Signal Output Resistance					
Terminal Numbers 8, 9, and 10 (r_o)			5		

Note 1: $\Delta V_8 = V_8 - \left(\frac{V_8 + V_9 + V_{10}}{3}\right), \Delta V_9 = V_9 - \left(\frac{V_8 + V_9 + V_{10}}{3}\right), \Delta V_{10} = V_{10} - \left(\frac{V_8 + V_9 + V_{10}}{3}\right)$

Note 2: Terminal No. 3 is phase reference

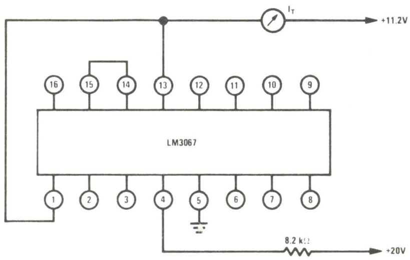
Note 3: Read phase shift as tint control is varied

block and functional diagram

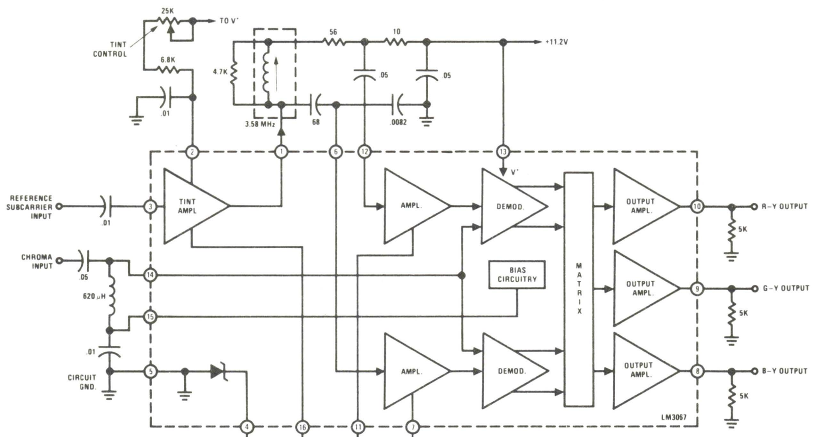


All resistance values are in ohms.
Unless otherwise indicated, all capacitance values less than 1.0 are in microfarads 1.0 or greater are in picofarads.

test circuits



TEST CIRCUIT 1



Note 1: Reference subcarrier input (V_3) is a 3.58 MHz CW signal from 50Ω source.
Note 2: Chroma input (V_{14}) is a 3.53 MHz CW signal from 50Ω source.
Note 3: Phase and amplitude at terminal numbers 1, 3, 6, and 12 measured with HP8405A (or equivalent) vector voltmeter.
Note 4: Signals at terminal numbers 8, 9, and 10 measured with HP400E (or equivalent) voltmeter or an oscilloscope.
Note 5: Tint control at maximum unless otherwise noted.

All resistance values are in ohms.
Unless otherwise indicated, all capacitance values less than 1.0 are in microfarads 1.0 or greater are in picofarads.

TEST CIRCUIT 2

5

Consumer Circuits

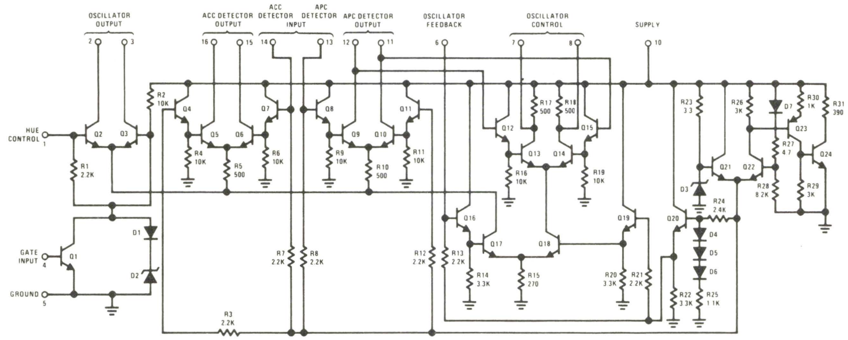
LM3070 chroma subcarrier regenerator

general description

The LM3070 integrated circuit is a phase locked loop oscillator controlled by an Automatic Phase Control (APC) detector, and an Automatic Chroma Control (ACC) detector which generates the correction voltage for the ACC amplifier of the LM3071. Both the APC and the ACC detectors are piloted by the burst signal present in the NTSC color video signal applied at Pins 13 and 14 in quadrature. The APC error output voltage controls the phase shift at Pin 7 in the oscillator feedback loop and locks the frequency of oscillation to the burst signal frequency. The APC and ACC detectors are keyed by the horizontal pulse applied at Pin 4, which also inhibits the oscillator output amplifier during the burst interval. Balance adjustment of DC offsets are provided to establish an initial no-signal offset control in the ACC output, and a no-signal, on-frequency adjustment through the APC detector-amplifier circuit which controls the oscillator frequency. The oscillator output stage is differentially controlled at Pins 2 and 3 by the HUE control to Pin 1.

The circuit also includes a shunt regulator to establish a 12V DC supply.

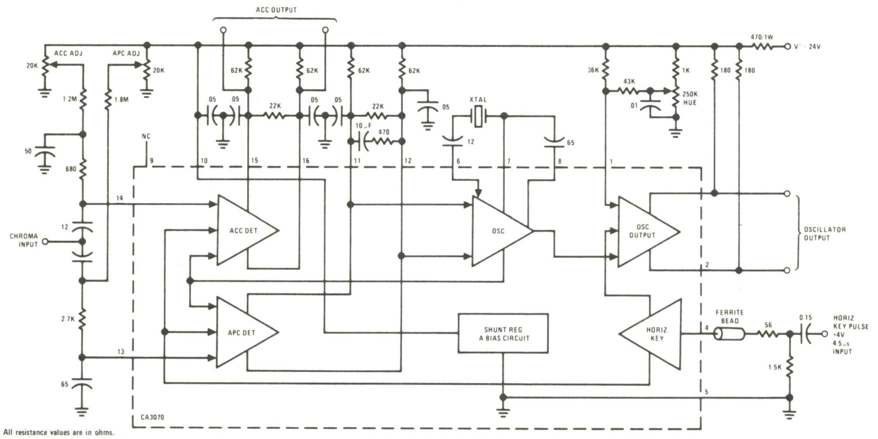
schematic diagram



Order Number LM3070N
See Package 23

Order Number LM3070N-01
See Package 25

block diagram



All resistance values are in ohms.
Unless otherwise indicated, all capacitance values less than 10 are in microfarads, 10 or greater are in picofarads.

absolute maximum ratings

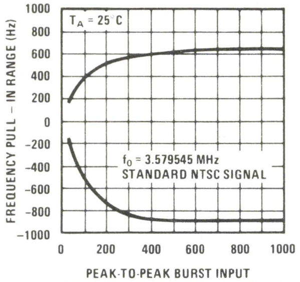
Supply Current	40 mA
Internal Power Dissipation up to 70°C	550 mW
Above 70°C Derate at 7 mW/°C	
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

electrical characteristics $T_A = 25°C$ $V^+ = 24V$

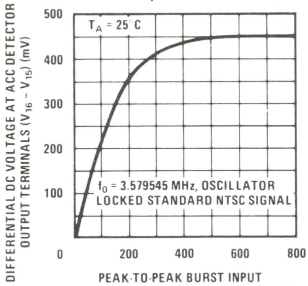
PARAMETER	SYMBOL	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
STATIC (Refer to Test Circuit 1)						
Supply Current	I_S			25.5		mA
Voltage at Supply Terminal	V_{10}		11.3	12	12.8	V
Supply Regulation	ΔV_{10}	$V^+ = 21V$ to $V^+ = 27V$		30		mV
Total Current into Oscillator Output Terminals	$I_2 + I_3$	S_1 "OFF", S_2 Position 1, Pins 2 and 3 shorted together	4.2	5.8	7.8	mA
APC Output Current	I_{11}, I_{12}	S_1 "ON", S_2 Position 1		1.45		mA
ACC Output Current	I_{15}, I_{16}	S_1 "ON", S_2 Position 1		1.45		mA
APC Output Balance	$V_{11} - V_{12}$	S_1 "ON", S_2 Position 1	-350	0	+350	mV
ACC Output Balance	$V_{15} - V_{16}$	S_1 "ON", S_2 Position 1	-300	0	+300	mV
Oscillator Control Balance	$V_7 - V_8$	S_2 Position 2, $V_{11} = V_{12} = 9.5V$	-300	0	+300	mV
Voltage at Hue Control Terminal	V_1	S_1 "OFF"	7.1	7.7	8.3	V
Voltage at Oscillator Feedback Terminal	V_6	S_2 Position 3		2.8		V
Voltage at APC and ACC Input Terminal	V_{13}, V_{14}		5.8	6.3	6.9	V
DYNAMIC (Refer to Test Circuit 2)						
Oscillator Pullin Range				±650		Hz
Oscillator Control Sensitivity				12		Hz/mV
Oscillator Output at Pin 2	V_2	S_1, Position 1	.75	1.0		V_{p-p}
Oscillator Output at Pin 3	V_3	S_1, Position 2	.75	1.0		V_{p-p}
ACC Detected Output			120	150		mV

typical performance characteristics

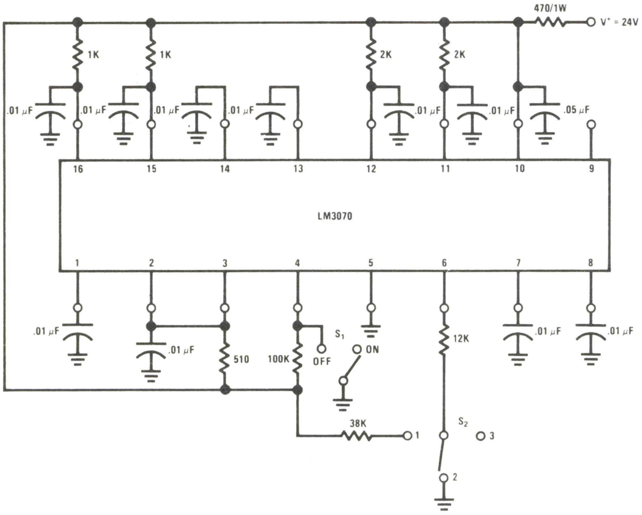
Frequency Pull-In Range as a Function of Burst Input Level



Differential DC Voltage at ACC Detector Output as a Function of Burst Input Level

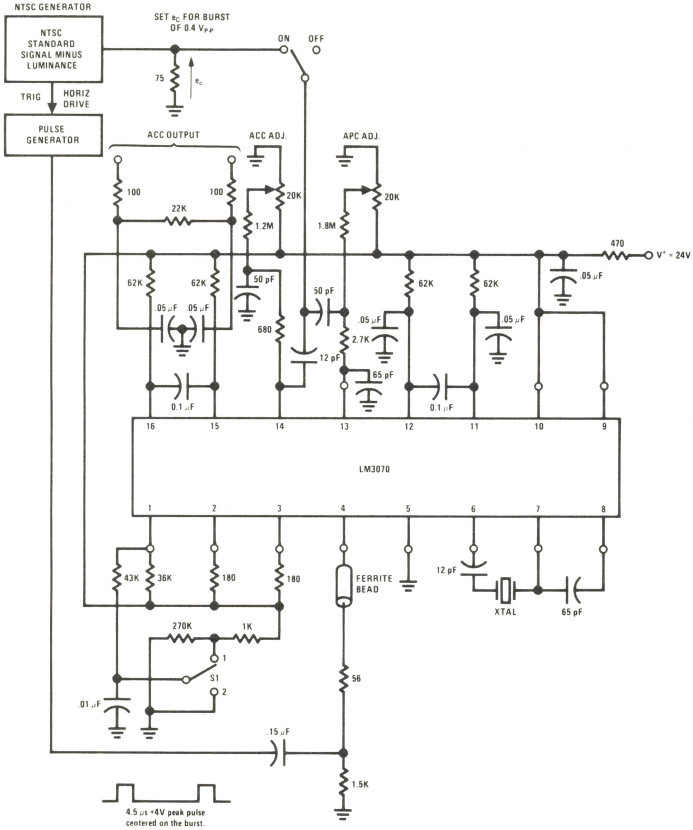


dc test circuit



TEST CIRCUIT 1

ac test circuit



TEST CIRCUIT 2

Consumer Circuits

LM3071 television chroma IF amplifier

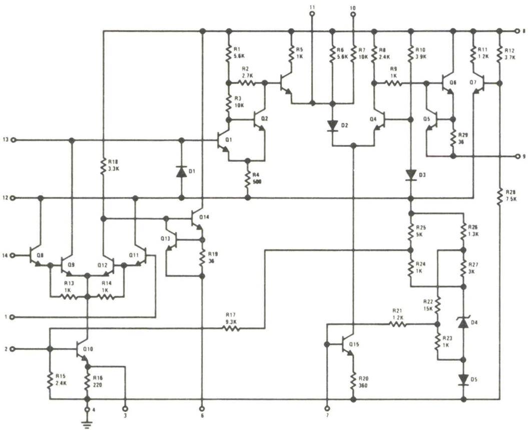
general description

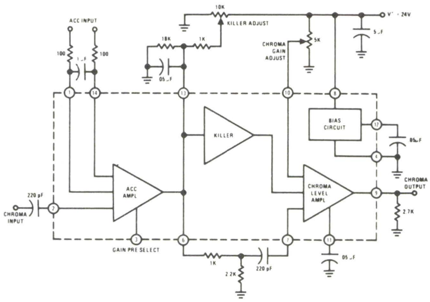
The LM3071 is a two stage chroma IF amplifier on a single silicon chip encapsulated in a 14 lead molded-Dual-In-Line Package. The first stage is an automatic gain controlled amplifier, and its output from Pin 6 is used to drive the ACC detector of the LM3070 or an equivalent circuit. The output from the ACC detector is applied to Pins 1 and 14 to control the gain of the stage. The second amplifier stage is driven from the output of the first at Pin 7, and the gain is controlled by adjusting the DC voltage at Pin 10. The output from Pin 9 supplies the chroma drive signal to the chroma demodulator circuit. In addition, the second stage may be gated "OFF" to provide "color killing" action in the absence of color signal at the output of the first stage. The killer trip point is adjusted externally.

features

- Very effective gain control of both stages
- Good signal handling capability
- Excellent gain stability with temperature and supply voltage variations
- Low distortion

schematic and functional diagrams

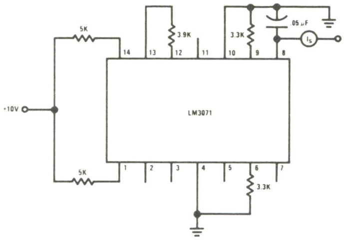




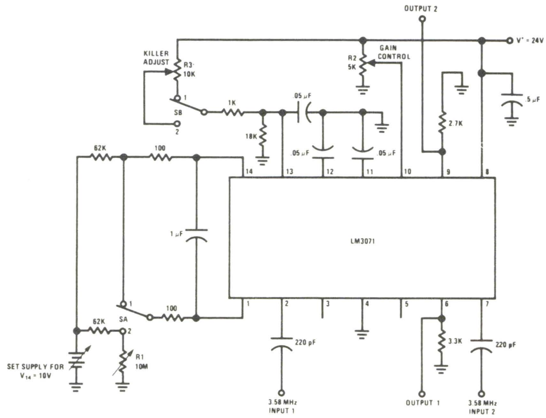
Order Number LM3071N
See Package 22

Order Number LM3071N-01
See Package 24

test circuits



Test Circuit 1



Test Circuit 2

absolute maximum ratings

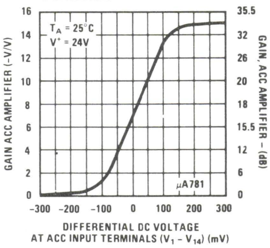
Supply Voltage	$V^+ = 30V$
Internal Power Dissipation at 70°C	550 mW
Above 70°C derate at 7 mW/°C	
Operating Temperature	−40°C to +85°C
Storage Temperature	−65°C to +150°C

electrical characteristics $T_A = 25°C$ $V^+ = 24V$

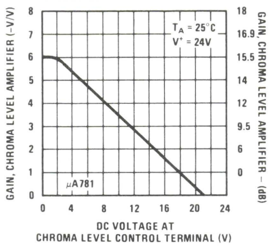
PARAMETER	SYMBOL	CONDITIONS	LIMITS MIN	TYP	MAX	UNIT
STATIC (Refer to Test Circuit 1)						
Supply Current	I_S		17	24	31	mA
Bias Voltage at Pin 12	V_{12}		14	15.3	16.5	V
Voltage at Input 1	V_2			1.7		V
Voltage at Input 2	V_7			1.4		V
Voltage at Output 1	V_6	$V_{ACC} = V_1 - V_{14} = 0V$	15.5	17.5	20	V
Voltage at Output 2	V_9	$V_{10} = 0V$	17.25	18.25	19	V
DYNAMIC (Refer to Test Circuit 2) f = 3.58 MHz						
Gain, ACC Amplifier Stage	A_{V1}	S_A Position 1, $V_1 = V_{14} = 10V$	14	16.5	19	db
Gain Reduction of ACC Amplifier		S_A Position 2, R_1 set for $V_{14} - V_1 = 75$ mV		14		db
Maximum Gain, Chroma Level Amplifier	A_{V2}	S_B Position 1, $V_{10} = 0V$	13	15.5	17	db
90% Chroma Gain Control Reference Voltage	V_{10}	S_B Position 1, R_2 set for 90% of Maximum Gain	2.3	3.5	4.8	V_{DC}
10% Chroma Gain Control Reference Voltage	V_{10}	S_B Position 1, R_2 Set for 10% of Maximum Gain	17	20	21.7	V_{DC}
Maximum Chroma Output Before Distorting	V_9	S_B Position 1, $V_{10} = 0V$		5.5		V_{p-p}
ACC Amplifier Bandwidth	BW_1	S_A Position 1		12		MHz
Level Amplifier Bandwidth	BW_2			30		MHz
Killer on Threshold	V_{13}	S_B Position 2, Adjust R_3 to Kill Output		16.5		V_{DC}
Gain Variation with V^+, Level Amplifier Stage	ΔA_{V2}	R_2 set for 10% of maximum Gain $V^+ = 24 \pm 3V$		0.3		db
Gain Variation with Temperature, Level Amplifier Stage	ΔA_{V2}	R_2 set for 10% of Maximum Gain $T_A = 25°C$ to $T_A = 70°C$		0.5		db
ACC Amplifier Input Resistance	R_i1			2.0		kΩ
ACC Amplifier Input Capacitance	C_i1			5		pF
Level Amplifier Input Resistance	R_i2			2.2		kΩ
Level Amplifier Input Capacitance	C_i2			4.2		pF

typical performance characteristics

ACC Amplifier Gain as a Function of Differential DC Voltage at ACC Input Terminals



Chroma Level Amplifier Gain as a Function of DC Voltage at Chroma Level Control Terminal



Consumer Circuits

LM3075 FM detector/limiter and audio preamplifier

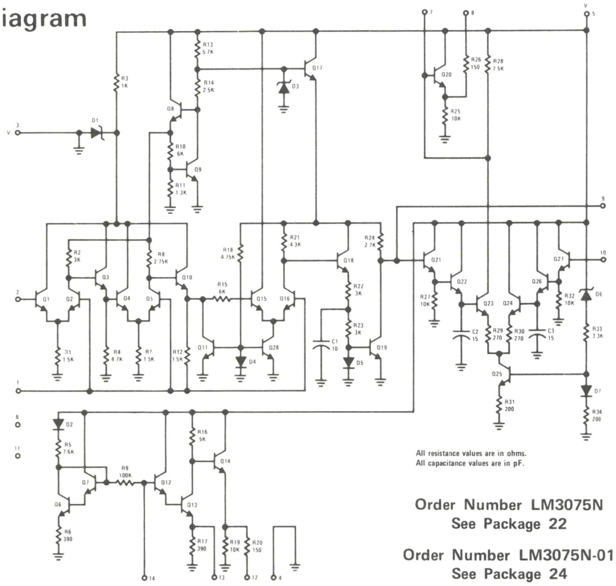
general description

The LM3075 is a monolithic integrated circuit FM detector/limiter and audio preamplifier that requires a minimum of external components for operation. It includes three stages of IF limiting and a differential-peak-detection circuit.

features

- A direct replacement for the CA3075
- Simple detector alignment: one coil
- Sensitivity: 3 dB limiting voltage 250 μV typical at 10.7 MHz
- Low harmonic distortion
- Excellent AM rejection 55 dB typ. at 10.7 MHz
- Internal audio preamplifier

schematic diagram

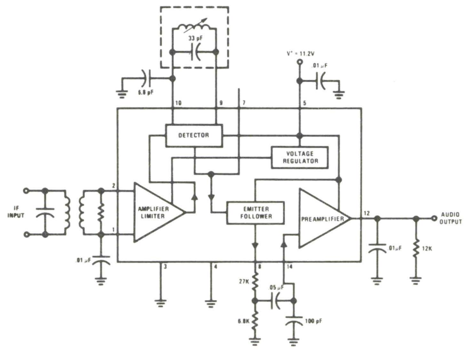


All resistance values are in ohms.
All capacitance values are in pF.

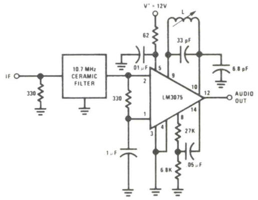
Order Number LM3075N
See Package 22

Order Number LM3075N-01
See Package 24

block diagram



typical application



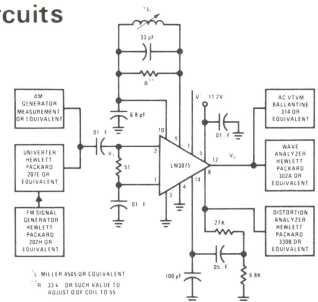
absolute maximum ratings

Power Supply Current (Pin 5)	30 mA	Operating Temperature Range	−40°C to +85°C
Supply Voltage (Pin 5)	12.5V	Storage Temperature Range	−65°C to +150°C
Power Dissipation		Lead Temperature (Soldering, 10 sec)	300°C
T_A = 25°C or less	850 mW		
T_A = 25°C or more	Derate Linearly 6.67 mW/°C		

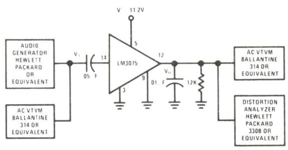
electrical characteristics $T_A = 25°C$

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS			UNITS
				MIN	TYP	MAX	
STATIC CHARACTERISTICS							
Supply Current	I_5		V_{CC} = 8.5V	8.5	15		mA
			V_{CC} = 11.2V		17.5		mA
			V_{CC} = 12.5V		19	29	mA
Detector Output Level (High)	V_7				6.1		V
Detector Output Level (Low)	V_8		V_{CC} = 11.2V		5.4		V
Audio Amplifier Output Level	V_{12}				5.2		V
DYNAMIC CHARACTERISTICS AT V^+ = 11.2V, f_0 = 10.7 MHz, Δf = ±75 kHz, fm = 400 Hz							
Input Limiting Threshold	$V_{IN(LIM)}$	1			250	600	µV
AM Rejection	AMR	1	AM: 1 kHz @ 30%, V_{IN} = 100 mV		55		dB
Recovered AF Voltage (At Terminal 12)	V_0 (AF)	1			1.5		V
Total Harmonic Distortion	T_{HD}	1			1	2	%
Audio Preamplifier							
Voltage Gain	$A_{V(af)}$	2	V_{IN} = 100 mV, f = 400 Hz		21		dB
Total Harmonic Distortion	T_{HD}	2	V_{OUT} = 2V, f = 400 Hz		1.5	5	%

test circuits



TEST CIRCUIT 1



TEST CIRCUIT 2

Transistor/Diode Arrays

LM114/LM114A/LM115/LM115A matched dual monolithic transistors

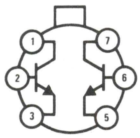
general description

These devices contain a pair of junction-isolated NPN transistors fabricated on a single silicon substrate. This monolithic structure makes possible extremely-tight parameter matching at low cost. Further, advanced processing techniques yield exceptionally high current gains at low collector currents, virtual elimination of "popcorn noise," low leakages and improved long-term stability. Some of the major features of these pairs are indicated by the following specifications:

- Low offset voltage—0.5 mV maximum
- Low drift—2 μV/°C maximum from −55°C to 125°C
- High current gain—500 minimum at 10 μA
- Tight beta match—10% maximum
- High breakdown voltage—to 60V
- Matching guaranteed over a 0V to 45V collector-base voltage range.

Although designed primarily for high breakdown voltage and exceptional dc characteristics, these transistors have surprisingly good high-frequency performance. The gain-bandwidth product is 450 MHz with 1 mA collector current and 5V collector-base voltage and 22 MHz with 10 μA collector current. Collector-base capacitance is only 1.3 pF at 5V.

connection diagram



TOP VIEW

Order Number LM114H or LM114AH
LM115H or LM115AH
See Package 10

absolute maximum ratings

	LM114 LM114A	LM115 LM115A
Collector-Base Voltage (BV_{CBO})	45V	60V
Collector-Emitter Voltage (BV_{CER})	45V	60V
Collector-Collector Voltage	45V	60V
Emitter-Emitter Voltage	45V	60V
Emitter-Base Voltage (BV_{EBO})	6V	
Collector Current	20 mA	
Total Power Dissipation (Note 1)	1.8W	
Operating Junction Temperature	−55°C to 150°C	
Storage Temperature	−65°C to 150°C	
Lead Temperature (soldering, 10 sec)	300°C	

Note 1: The maximum dissipation given is for a 25°C case temperature. For operation under other conditions, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 70°C/W junction to case or 230°C/W junction to ambient.

6

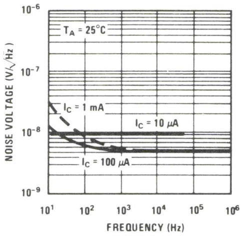
electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MAXIMUM LIMITS				UNITS
		LM114	LM114A	LM115	LM115A	
Offset Voltage	$1\ \mu A \le I_C \le 100\ \mu A$	2.0	0.5	2.0	0.5	mV
Offset Current	$I_C = 10\ \mu A$ $I_C = 1\ \mu A$	10	2.0 0.5	10	2.0 0.5	nA nA
Bias Current	$I_C = 10\ \mu A$ $I_C = 1\ \mu A$	40	20 3.0	40	40 6.0	nA nA
Offset Voltage Change	$0V \le V_{CB} \le V_{max}$ $I_C = 10\ \mu A$	1.5	0.2	2.0	0.3	mV
Offset Current Change	$0V \le V_{CB} \le V_{max}$ $I_C = 10\ \mu A$	4.0	1.0	4.0	1.0	nA
Offset Voltage Drift	$-55°C \le T_A \le 125°C$ $I_C = 10\ \mu A$	10	2.0	10	2.0	$\mu V/°C$
Offset Current	$-55°C \le T_A \le 125°C$ $I_C = 10\ \mu A$	50	12	50	20	nA
Bias Current	$-55°C \le T_A \le 125°C$ $I_C = 10\ \mu A$	150	60	150	150	nA
Collector-Base Leakage Current	$V_{CB} = V_{max}$ $T_A = 25°C$ $T_A = 125°C$	50 50	10 10	50 50	10 10	pA nA
Collector-Emitter Leakage Current	$V_{CE} = V_{max}$, $V_{EB} = 0$ $T_A = 25°C$ $T_A = 125°C$	200 200	50 50	200 200	50 50	pA nA
Collector-Collector Leakage Current	$V_{CC} = V_{max}$ $T_A = 25°C$ $T_A = 125°C$	300 300	100 100	300 300	100 100	pA nA

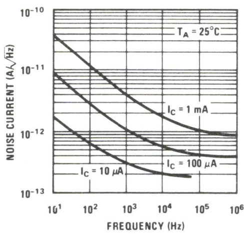
Note 2: These specifications apply for $T_A = 25°C$ and $0V \le V_{CB} \le V_{max}$, unless otherwise specified. For the LM114 and LM114A, $V_{max} = 30V$. For the LM115 and LM115A, $V_{max} = 45V$.

typical performance characteristics

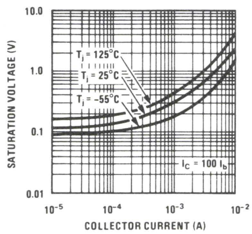
Noise Voltage



Noise Current



Saturation Voltage



Transistor/Diode Arrays

LM3018/LM3018A matched monolithic transistor arrays

general description

The LM3018 and LM3018A consist of four general purpose silicon NPN transistors on a common monolithic substrate. Two of the four transistors are connected in the Darlington configuration. The substrate is connected to a separate terminal for maximum flexibility. The transistors are well suited to a wide variety of applications in low-power systems in the DC through VHF range. They may be used as discrete transistors in conventional circuits but in addition they provide the advantages of close electrical and thermal matching inherent in integrated circuit construction.

features

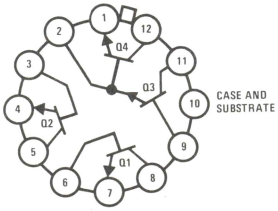
- Matched monolithic general purpose transistors
- H_{FE} matched ±10%
- V_{BE} matched
  - LM3018 ±5 mV
  - LM3018A ±2 mV
- Operation from DC to 120 MHz
- Wide operating current range
- LM3018A performance controlled from 10μA to 10 mA
- Low noise figure 3.2 dB typical at 1 kHz
- Full military temperature range capability −55°C to +125°C

applications

- General use in signal processing systems in DC through VHF range
- Custom designed differential amplifiers
- Temperature compensated amplifiers

schematic and connection diagram

Metal Can Package



TOP VIEW

Order Number LM3018H or LM3018AH

See Package 7

absolute maximum ratings

	LM3018	LM3018A
Power Dissipation (Note 1)		
Any One Transistor	300	300 mW
Total Package	450	450 mW
Operating Temperature Range		−55°C to +125°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

The following ratings apply for each transistor in the device:

	LM3018	LM3018A
Collector to Emitter Voltage, V_{CEO}	15	15V
Collector to Base Voltage, V_{CBO}	20	30V
Collector to Substrate Voltage, V_{CIO} (Note 2)	20	40V
Emitter to Base Voltage, V_{EBO}	5	5V
Collector Current, I_C	50	50 mA

dc electrical characteristics $T_A = 25°C$

PARAMETER	CONDITIONS	LIMITS LM3018 MIN	LM3018 TYP	LM3018 MAX	LM3018A MIN	LM3018A TYP	LM3018A MAX	UNITS
STATIC CHARACTERISTICS								
Collector Cutoff Current (I_{CBO})	V_{CB} = 10V, I_E = 0		.002	100		.002	40	nA
Collector Cutoff Current (I_{CEO})	V_{CE} = 10V, I_B = 0			5			.5	μA
Collector Cutoff Current Darlington Pair (I_{CEOD})	V_{CE} = 10V, I_B = 0						5	μA
Collector to Emitter Breakdown Voltage ($V_{(BR)CEO}$)	I_C = 1 mA, I_B = 0	15	24		15	24		V
Collector to Base Breakdown Voltage ($V_{(BR)CBO}$)	I_C = 10μA, I_E = 0	20	60		30	60		V
Emitter to Base Breakdown Voltage ($V_{(BR)EBO}$)	I_E = 10μA, I_C = 0	5	7		5	7		V
Collector to Substrate Breakdown Voltage ($V_{(BR)CIO}$)	I_C = 10μA, I_{CI} = 0	20	60		40	60		V
Collector to Emitter Saturation Voltage (V_{CES})	I_B = 1 mA, I_C = 10 mA		.23			.23	.5	V
Static Forward Current Transfer Ratio (h_{FE})	V_{CE} = 3V, I_C = 10 mA I_C = 1 mA I_C = 10μA	30	100 100 54		50 60 30	100 100 54		
Magnitude of Static Beta Ratio (Isolated Transistors Q_1 and Q_2)	V_{CE} = 3V, I_{C1} = I_{C2} = 1 mA	.9	.97		.9	.97		
Static Forward Current Transfer Ratio Darlington Pair (Q_3 and Q_4) (h_{FED})	V_{CE} = 3V, I_C = 1 mA I_C = 100μA	1500	5400		2000 1000	5400 2800		
Base to Emitter Voltage (V_{BE})	V_{CE} = 3V, I_E = 1 mA I_E = 10 mA		.715 .800		.600	.715 .800	.800 .900	V
Input Offset Voltage $\left(\lvert V_{BE_1} - V_{BE_2}\rvert\right)$	V_{CE} = 3V, I_E = 1 mA		.48	5		.48	2	mV
Temperature Coefficient: Base to Emitter Voltage Q_1, Q_2 $\left(\frac{\lvert\Delta V_{BE}\rvert}{\Delta T}\right)$	V_{CE} = 3V, I_E = 1 mA		−1.9			−1.9		mV/°C
Base (Q_3) to Emitter (Q_4) Voltage Darlington Pair (V_{BED} ($V_{9\text{-}1}$))	V_{CE} = 3V, I_E = 10 mA I_E = 1 mA		1.46 1.32		1.10	1.46 1.32	1.60 1.50	V
Temperature Coefficient: Base to Emitter Voltage Darlington Pair Q_3, Q_4 $\left(\frac{\lvert\Delta V_{BED}\rvert}{\Delta T}\right)$	V_{CE} = 3V, I_E = 1 mA		4.4			4.4		mV/°C
Temperature Coefficient: Magnitude of Input Offset Voltage $\left(\frac{\lvert V_{BE_1} - V_{BE_2}\rvert}{\Delta T}\right)$	V_{CC} = +6, V_{EE} = −6V I_{C_1} = I_{C_2} = 1 mA		10			10		μV/°C

ac electrical characteristics $T_A = 25°C$

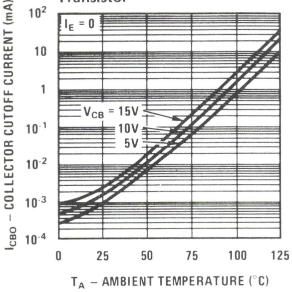
PARAMETER	CONDITIONS	LM3018 MIN	LM3018 TYP	LM3018 MAX	LM3018A MIN	LM3018A TYP	LM3018A MAX	UNITS
DYNAMIC CHARACTERISTICS								
Low Frequency Noise Figure (NF)	f = 1 kHz, V_{CE} = 3V, I_C = 100μA, Source Resistance = 1 kΩ		3.25			3.25		dB
Low Frequency, Small-Signal Equivalent Circuit Characteristics:								
Forward Current Transfer Ratio (h_{fe})	f = 1 kHz, V_{CE} = 3V, I_C = 1 mA		110			110		
Short Circuit Input Impedance (h_{ie})			3.5			3.5		kΩ
Open Circuit Output Impedance (h_{oe})			15.6			15.6		μmho
Open Circuit Reverse Voltage Transfer Ratio (h_{re})			1.8×10^{-4}			1.8×10^{-4}		
Admittance Characteristics:								
Forward Transfer Admittance (Y_{fe})	f = 1 MHz, V_{CE} = 3V, I_C = 1 mA		31 −j1.5			31 −j1.5		mmho
Input Admittance (Y_{ie})			.3 +j0.04			.3 +j0.04		mmho
Output Admittance (Y_{oe})			.001 +j0.03			.001 +j0.03		mmho
Reverse Transfer Admittance (Y_{re})			See Curve			See Curve		mmho
Gain Bandwidth Product (f_T)	V_{CE} = 3V, I_C = 3 mA	300	500		300	500		MHz
Emitter to Base Capacitance (C_{EB})	V_{EB} = 3V, I_E = 0		.6			.6		pF
Collector to Base Capacitance (C_{CB})	V_{CB} = 3V, I_C = 0		.58			.58		pF
Collector to Substrate Capacitance (C_{CI})	V_{CI} = 3V, I_C = 0		2.8			2.8		pF

Note 1: Derate at 5 mW/°C for T_A > 85°C

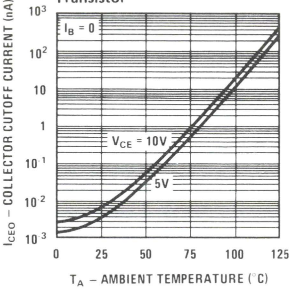
Note 2: The collector of each transistor of the LM3018 and LM3018A is isolated from the substrate by an integral diode. The substrate (terminal 10) must be connected to the most negative point in the external circuit to maintain isolation between transistors and to provide for normal transistor action.

typical performance characteristics

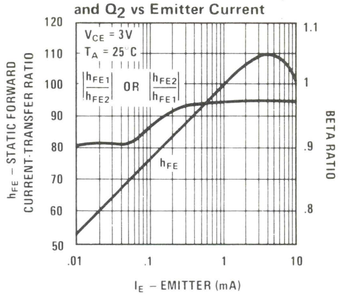
Typical Collector-To-Base Cutoff Current vs Ambient Temperature for Each Transistor



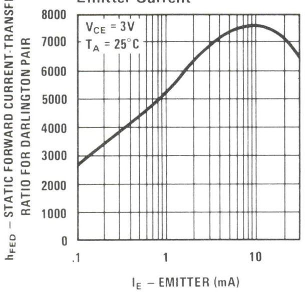
Typical Collector-To-Emitter Cutoff Current vs Ambient Temperature for Each Transistor



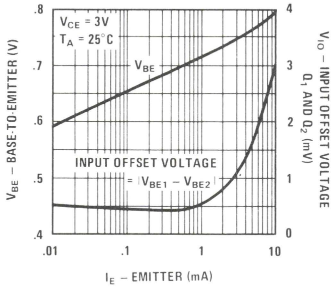
Typical Static Forward Current-Transfer Ratio and Beta Ratio for Transistors Q_1 and Q_2 vs Emitter Current



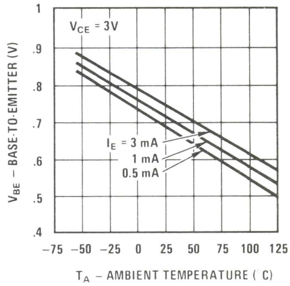
Typical Static Forward Current-Transfer Ratio for Darlington-connected Transistors Q_3 and Q_4 vs Emitter Current



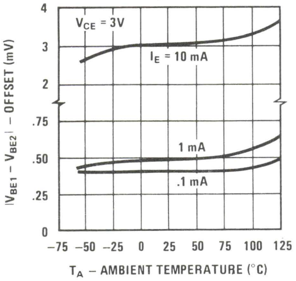
Typical Static Base-To-Emitter Voltage Characteristic and Input Offset Voltage for Q_1 and Q_2 vs Emitter Current



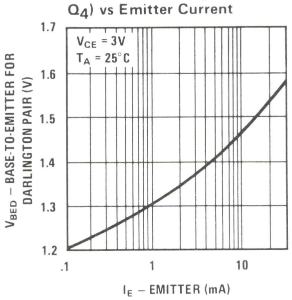
Typical Base-To-Emitter Voltage Characteristic for Each Transistor vs Ambient Temperature



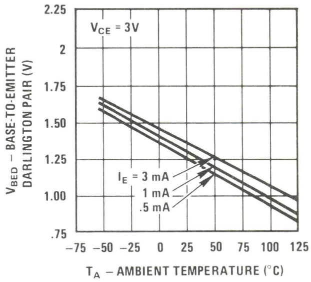
Typical Offset Voltage Characteristic vs Ambient Temperature



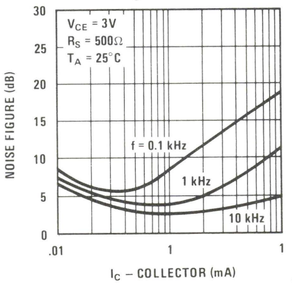
Typical Static Input Voltage Characteristic for Darlington Pair (Q_3 and Q_4) vs Emitter Current



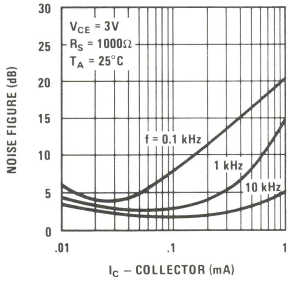
Typical Static Input Voltage Characteristic for Darlington Pair (Q_3 and Q_4) vs Ambient Temperature



Noise Figure vs Collector Current, $R_S = 500\Omega$

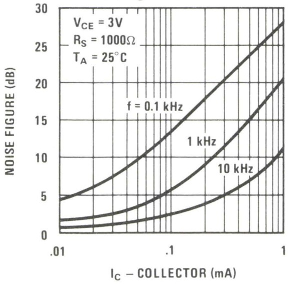


Noise Figure vs Collector Current, $R_S = 1k\Omega$

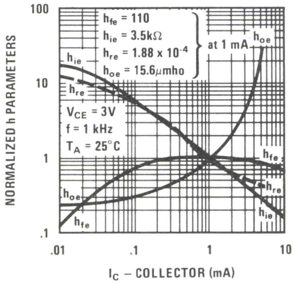


typical performance characteristics (con't)

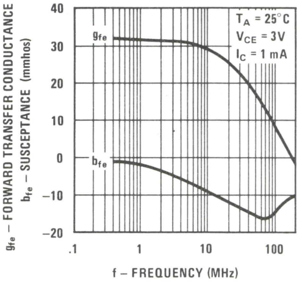
Noise Figure vs Collector Current, $R_S = 10k\Omega$



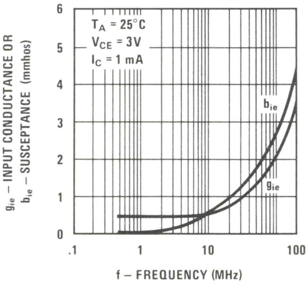
Forward Current-Transfer Ratio (h_{fe}), Short-Circuit Input Impedance (h_{ie}), Open-Circuit Output Impedance (h_{oe}), and Open-Circuit Reverse Voltage-Transfer Ratio (h_{re}) vs Collector Current



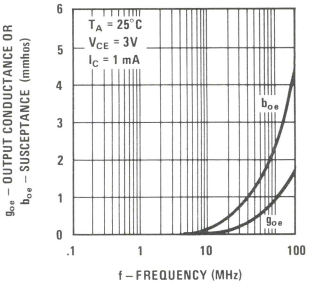
Forward Transfer Admittance (Y_{fe})



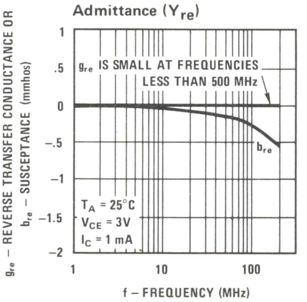
Input Admittance (Y_{ie})



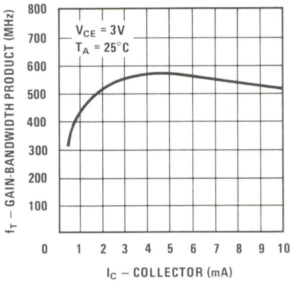
Output Admittance (Y_{oe})



Reverse Transfer Admittance (Y_{re})



Typical Gain-Bandwidth Product (f_T) vs Collector Current



Transistor/Diode Arrays

LM3019 diode array

general description

The LM3019 consists of one silicon diode "quad" and two isolated silicon diodes on a common monolithic substrate.

- 10-pin TO-5 package
- Hermetically sealed

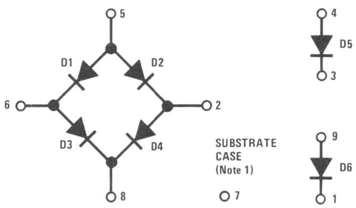
features

- Excellent diode match
- Low leakage current
- Low pedestal voltage when gating
- Built-in temperature stability for operation from −55°C to +125°C

applications

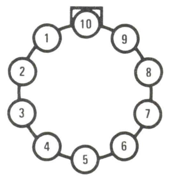
- Modulator
- Mixer
- Balanced modulator
- Analog switch
- Diode gate for chopper-modulator applications

schematic and connection diagrams



NOTE 1: CONNECT TO MOST NEGATIVE CIRCUIT POTENTIAL.

Metal Can Package



Order Number LM3019H
See Package 13

absolute maximum voltage limits $T_A = 25°C$

TERMINAL	VOLTAGE LIMITS		CONDITIONS	
	NEGATIVE	POSITIVE	TERMINAL	VOLTAGE
1	−3	+12	7	−6
2	−3	+12	7	−6
3	−3	+12	7	−6
4	−3	+12	7	−6
5	−3	+12	7	−6
6	−3	+12	7	−6
7	−18	0	1, 2, 3, 6, 8	0
8	−3	+12	7	−6
9	−3	+12	7	−6
10	NO CONNECTION			
CASE	INTERNALLY CONNECTED TO TERMINAL 7 **DO NOT GROUND**			

absolute maximum ratings

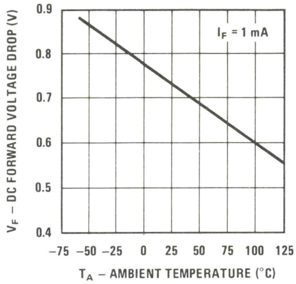
Power Dissipation	
Any One Diode Unit	20 mW
Total For Device	120 mW
Storage Temperature Range	−65°C to +200°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics for each diode unit, unless otherwise specified, $T_A = 25°C$.

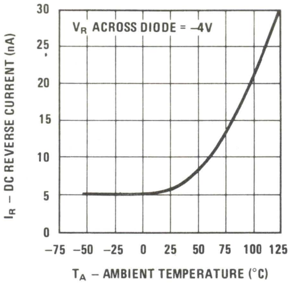
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Forward Voltage Drop (V_F)	DC Forward Current $I_F = 1$ mA		.73	.78	V
DC Reverse Breakdown Voltage ($V_{(BR)R}$)	DC Reverse Current $I_R = -10\mu A$	4	6		V
DC Reverse Breakdown Voltage Between Any Diode Unit and Substrate ($V_{(BR)R}$)	DC Reverse Current $I_R = -10\mu A$	25	80		V
DC Reverse (Leakage) Current (I_R)	DC Reverse Voltage $V_R = -4V$		.0055	10	μA
DC Reverse (Leakage) Current Between Any Diode Unit and Substrate (I_R)	DC Reverse Voltage $V_R = -4V$		.010	10	μA
Magnitude of Diode Offset Voltage (Difference in DC Forward Voltage Drops of Any Two Diode Units) ($\lvert V_{F_1} - V_{F_2} \rvert$)	DC Forward Current $I_F = 1$ mA		1	5	mV
Single Diode Capacitance	Frequency f = 1 MHz DC Reverse Voltage $V_R = -2V$		1.8		pF
Diode Quad-to-Substrate Capacitance (C_{DQ-1})	Frequency f = 1 MHz DC Reverse Voltage V_R Between Terminal 2, 5, 6 or 8 of Diode Quad and Terminal 7 Substrate = −2V				
	Terminal 2 or 6 to Terminal 7		4.4		pF
	Terminal 5 or 8 to Terminal 7		2.7		pF
Series Gate Switching Pedestal Voltage (V_S)			10		mV

typical performance characteristics

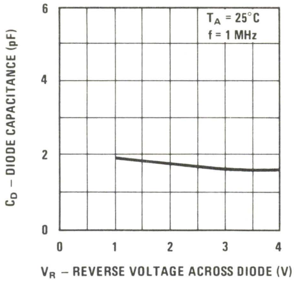
DC Forward Voltage Drop (Any Diode) vs Temperature



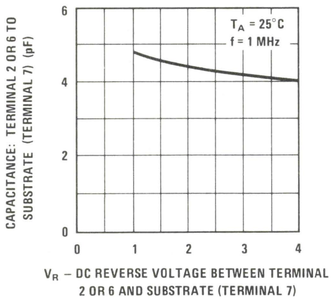
Reverse (Leakage) Current (Any Diode) vs Temperature



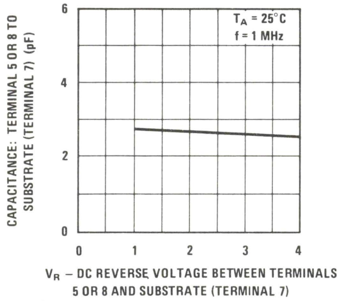
Diode Capacitance (Any Diode) vs Reverse Voltage



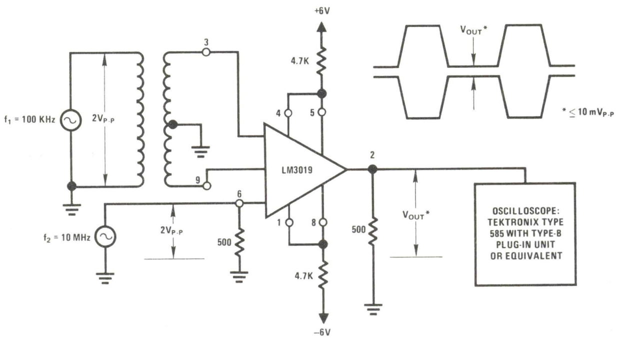
Diode Quad-To-Substrate Capacitance vs Reverse Voltage



Diode Quad-To-Substrate Capacitance vs Reverse Voltage



series gate switching test setup



Transistor/Diode Arrays

LM3026, LM3054 transistor arrays

general description

The LM3026 and LM3054 each consists of two independent differential amplifiers with associated constant-current transistors on a common monolithic substrate. The six NPN transistors which comprise the amplifiers are general purpose devices which exhibit low 1/f noise and a value of f_T in excess of 300 MHz. These features make the LM3026 and LM3054 useful from DC to 120 MHz. Bias and load resistors have been omitted to provide maximum application flexibility.

The monolithic construction of the LM3026 and LM3054 provides close electrical and thermal matching of the amplifiers. This feature makes these devices particularly useful in dual channel applications where matched performance of the two channels is required.

The LM3026 is supplied in a hermetic 12-lead TO-5 style package and is rated for full military operating temperature range of −55°C to +125°C.

The LM3054 is supplied in a 14-lead molded dual-in-line package with a limited temperature range. The availability of extra terminals allows the introduction of an independent substrate connection for maximum flexibility.

features

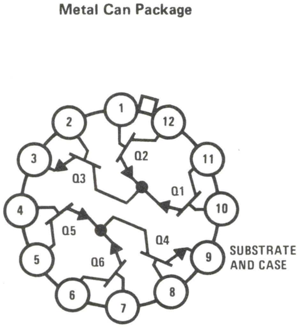
- Two differential amplifiers on a common substrate
- Independently accessible inputs and outputs
- Maximum input offset voltage ±5 mV
- Full military temperature range capability −55°C to +125°C
- Limited temperature range, LM3054 0°C to +85°C

applications

- Dual sense amplifiers
- Dual Schmitt triggers
- Multifunction combinations RF mixer oscillator converter IF
- IF amplifiers (differential and or cascade)
- Product detectors
- Doubly balanced modulators and demodulators
- Balanced quadrature detectors
- Cascade limiters
- Synchronous detectors
- Pairs of balanced mixers
- Synthesizer mixers
- Balanced (push-pull) cascode amplifiers

schematic and connection diagrams

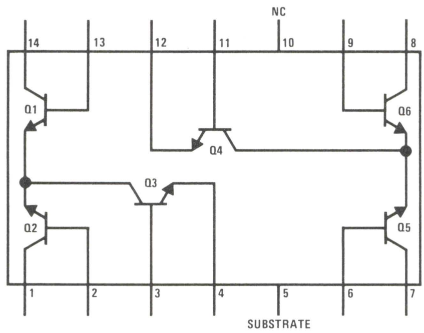
Metal Can Package



TOP VIEW

Order Number LM3026H
See Package 7

Dual-In-Line Package



TOP VIEW

Order Number LM3054N
See Package 22

absolute maximum ratings ($T_A = 25°C$)

	LM3026	LM3054
Power Dissipation		
Any One Transistor	300 mW	300 mW
Total Package	600 mW	750 mW
For $T_A > 55°C$	Derate at 5 mW/°C	6.67 mW/°C
Operating Temperature Range	−55°C to +125°C	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

The following ratings apply for each transistor in the device:

Collector to Emitter Voltage (V_{CEO})	15V
Collector to Base Voltage (V_{CBO})	20V
Collector to Substrate Voltage (V_{CIO}) (Note)	20V
Emitter to Base Voltage (V_{EBO})	5V
Collector Current	50 mA

dc electrical characteristics ($T_A = 25°C$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
STATIC CHARACTERISTICS					
For Each Differential Amplifier					
Input Offset Voltage (V_{IO})			.45	5	mV
Input Offset Current (I_{IO})			.3	2	μA
Input Bias Current (I_I)	$V_{CB} = 3V$		10	24	μA
Quiescent Operating Current Ratio $\left(\frac{I_{C(Q1)}}{I_{C(Q2)}} \text{ or } \frac{I_{C(Q5)}}{I_{C(Q6)}}\right)$	$I_{E(Q3)} = I_{E(Q4)} = 2$ mA		.98 to 1.02		
Temperature Coefficient Magnitude of Input Offset Voltage $\left(\frac{\lvert\Delta V_{IO}\rvert}{\Delta T}\right)$			1.1		μV/°C
For Each Transistor					
DC Forward Base to Emitter Voltage (V_{BE})	$V_{CB} = 3V$, $I_C = 50\ \mu A$		.630	.700	V
	1 mA		.715	.800	V
	3 mA		.750	.850	V
	10 mA		.800	.900	V
Temperature Coefficient of Base to Emitter Voltage $\left(\frac{\Delta V_{BE}}{\Delta T}\right)$	$V_{CB} = 3V$, $I_C = 1$ mA		−1.9		μV/°C
Collector Cutoff Current (I_{CBO})	$V_{CB} = 10V$, $I_E = 0$		.002	100	nA
Collector to Emitter Breakdown Voltage ($V_{(BR)CEO}$)	$I_C = 1$ mA, $I_B = 0$	15	24		V
Collector to Base Breakdown Voltage ($V_{(BR)CBO}$)	$I_C = 10\mu A$, $I_E = 0$	20	60		V
Collector to Substrate Breakdown Voltage ($V_{(BR)CIO}$)	$I_C = 10\mu A$, $I_{CI} = 0$	20	60		V
Emitter to Base Breakdown Voltage ($V_{(BR)EBO}$)	$I_E = 10\mu A$, $I_C = 0$	5	7		V

ac electrical characteristics

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DYNAMIC CHARACTERISTICS					
Common Mode Rejection Ratio For Each Amplifier (CMR)			100		dB
AGC Range, One Stage (AGC)	$V_{CC} = 12V$, $V_{EE} = -6V$, $V_x = -3.3V$, f = 1 kHz		75		dB
Voltage Gain, Single Stage Double Ended Output (A)			32		dB
AGC Range, Two Stage (AGC)			105		dB
Voltage Gain, Two Stage Double Ended Output (A)			60		dB
Low-Frequency, Small Signal Equivalent Circuit Characteristics: (For Single Transistor)					
Forward Current Transfer Ratio (h_{fe})	f = 1 kHz, $V_{CE} = 3V$, $I_C = 1$ mA		110		
Short Circuit Input Impedance (h_{ie})			3.5		kΩ
Open Circuit Output Impedance (h_{oe})			15.6		μmho
Open Circuit Reverse Voltage Transfer Ratio (h_{re})			1.8×10^{-4}		
1/f Noise Figure (For Single Transistor) (NF)	f = 1 kHz, $V_{CE} = 3V$		3.25		dB
Gain Bandwidth Product (For Single Transistor) (f_T)	$V_{CE} = 3V$, $I_C = 3$ mA		550		MHz
Admittance Characteristics; Differential Circuit Configuration: (For Each Amplifier)					

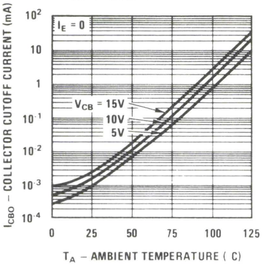
Note: The collector of each transistor of the LM3026 and LM3054 is isolated from the substrate by an integral diode. The substrate must be connected to a voltage which is more negative than any collector voltage in order to maintain isolation between transistors and provide for normal transistor action. The substrate should be maintained at signal (AC) ground by means of a suitable grounding capacitor, to avoid undesired coupling between transistors.

ac electrical characteristics (con't)

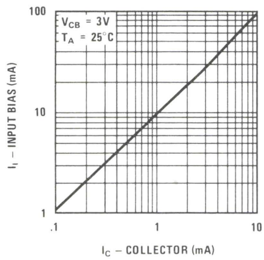
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Forward Transfer Admittance (y_{21})	V_{CB} = 3V Each Collector $I_C \approx$ 1.25 mA f = 1 MHz		−20 + j0		mmho
Input Admittance (y_{11})			.22 + j0.1		mmho
Output Admittance (y_{22})			.01 + j0		mmho
Reverse Transfer Admittance (y_{12})			−0.003 + j0		mmho
Admittance Characteristics; Cascode Circuit Configuration: (For Each Amplifier)					
Forward Transfer Admittance (y_{21})	V_{CB} = 3V Total Stage $I_C \approx$ 2.5 mA f = 1 MHz		68 − j0		mmho
Input Admittance (y_{11})			.55 + j0		mmho
Output Admittance (y_{22})			0 + j0.02		mmho
Reverse Transfer Admittance (y_{12})			.004 − j.005		μmho
Noise Figure (NF)	f = 100 MHz		8		dB

typical performance characteristics

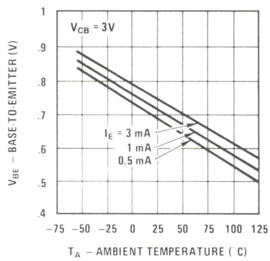
Collector-To-Base Cutoff Current vs Ambient Temperature for Each Transistor



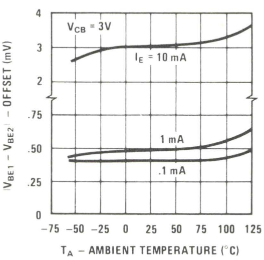
Input Bias Current Characteristic vs Collector Current for Each Transistor



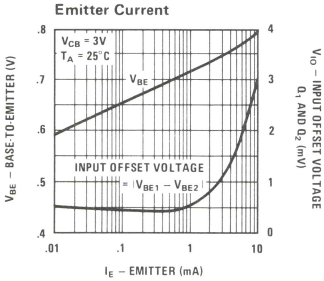
Base-To-Emitter Voltage Characteristic for Each Transistor vs Ambient Temperature



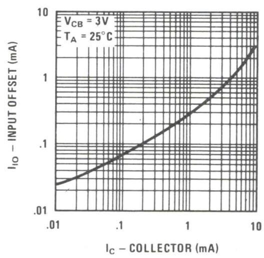
Offset Voltage Characteristic vs Ambient Temperature for Differential Pairs



Static Base-To-Emitter Voltage Characteristic and Input Offset Voltage for Differential Pairs vs Emitter Current

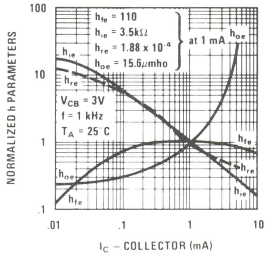


Input Offset Current for Matched Differential Pairs vs Collector Current

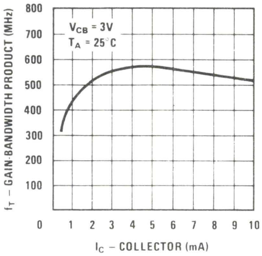


typical performance characteristics (con't)

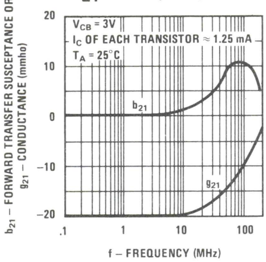
Forward Current-Transfer Ratio (h_{fe}), Short-Circuit Input Impedance (h_{ie}), Open-Circuit Output Impedance (h_{oe}), and Open-Circuit Reverse Voltage-Transfer Ratio (h_{re}) vs Collector Current for Each Transistor



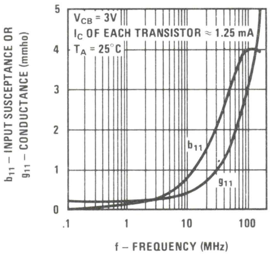
Gain-Bandwidth Product (f_T) vs Collector Current



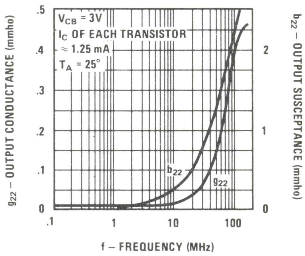
Forward Transfer Admittance (Y_{21}) vs Frequency



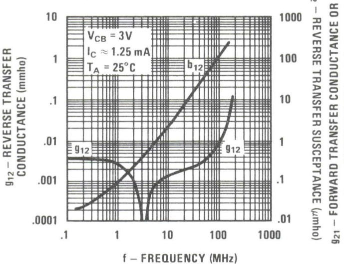
Input Admittance (Y_{11})



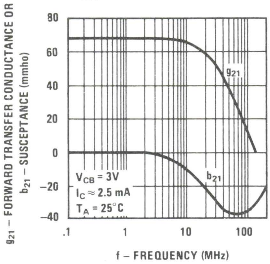
Output Admittance (Y_{22}) vs Frequency



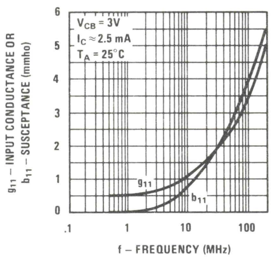
Reverse Transfer Admittance (Y_{12}) vs Frequency



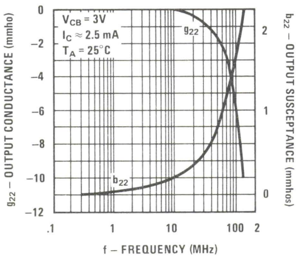
Forward Transfer Admittance (Y_{21}) vs Frequency



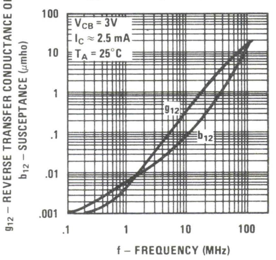
Input Admittance (Y_{11}) vs Frequency



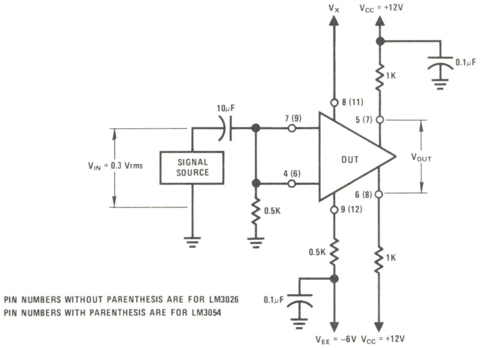
Output Admittance (Y_{22}) vs Frequency



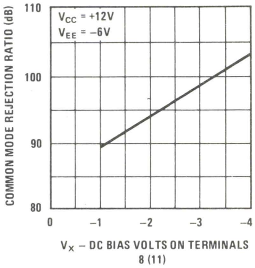
Reverse Transfer Admittance (Y_{12}) vs Frequency

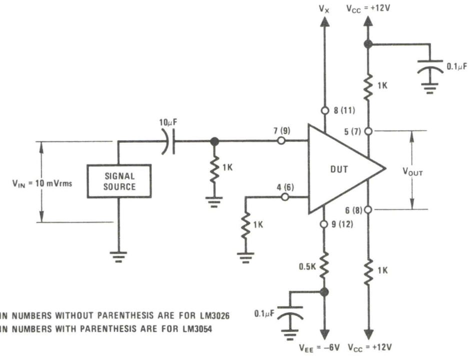


typical performance characteristics (con't)

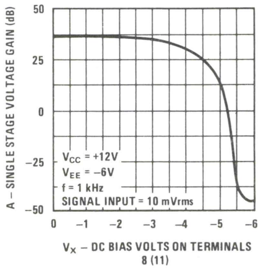


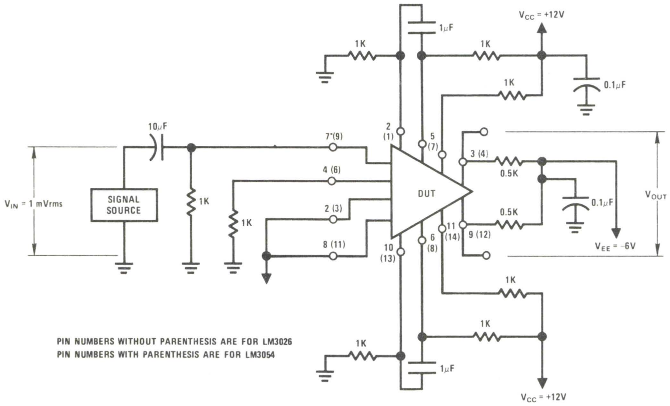
Common Mode Rejection Ratio



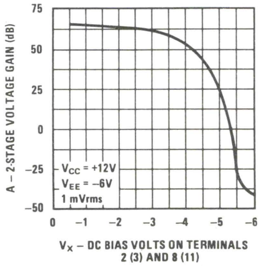


Single-Stage Voltage Gain





Two-Stage Voltage Gain



The following chart gives the range of voltages which can be applied to the terminals listed vertically with respect to the terminals listed horizontally. For example, the voltage range between vertical terminal 1† and horizontal terminal 3† is +15V to −5V.

LM3054 TERMINAL NO. →		13	14	1	2	3	4	6	7	8	9	11	12	5
↓	LM3026 TERMINAL NO.	10	11	12	1	2	3	4	5	6	7	8	(Note 2) 9	(Note 2) 9
13	10		0 −20	*	+5 −5	*	+15 −5	*	*	*	*	*	*	*
14	11			*	*	*	+20 0	*	*	*	*	*	*	+20 0
1	12				+20 0	*	+20 0	*	*	*	*	*	*	+20 0
2	1					*	+15 −5	*	*	*	*	*	*	*
3	2						+1 −5	*	*	*	*	*	*	*
4	3							*	*	*	*	*	*	*
6	4								0 −20	*	+5 −5	*	+15 −5	*
7	5									*	*	*	*	+20 0
8	6										−20 0	*	*	+20 0
9	7											*	+15 −5	*
11	8												+1 −5	*
12	9													*
5	9													Ref Substrate

LM3054 TERMINAL NO. (Note 2)	LM3026 TERMINAL NO.	I_{IN} mA	I_{OUT} mA
13	10	5	.1
14	11	50	.1
1	12	50	.1
2	1	5	.1
3	2	5	.1
4	3	.1	−50
6	4	5	.1
7	5	50	.1
8	6	50	.1
9	7	5	.1
11	8	5	.1
12	9	.1	50

Note 1: In the LM3026 terminal No. 9 is connected to the emitter of Q_4, the reference substrate, and the case; therefore, the case should not be grounded. Two terminal 9 columns LM3026 appear in the voltage rating chart because it is a composite chart for both the LM3026 and the LM3054. Wherever an asterisk is shown in one column 9 and a rating is shown in the other column 9, the asterisk should be ignored.

Note 2: Terminal No. 10 of LM3054 is not used.

† LM3026; corresponding terminals for LM3054 are vertical terminal 2 and horizontal terminal 4.

*Voltages are not normally applied between these terminals. Voltages appearing between these terminals will be safe if the specified limits between all other terminals are not exceeded.

6

Transistor/Diode Arrays

LM3039 diode array

general description

The LM3039 consists of six ultra-fast, low capacitance silicon diodes on a common monolithic substrate. Five of the diodes are independently accessible, the sixth shares a common terminal with the substrate. Integrated circuit construction assures excellent static and dynamic matching of the diodes, making the array extremely useful for a wide variety of applications in communication and switching systems.

features

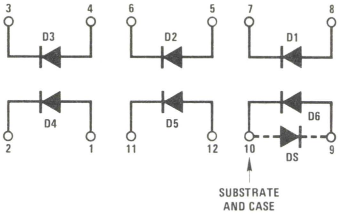
- Excellent reverse recovery time — 1 ns typ
- Matched monolithic construction — V_F matched within 5 mV
- Low diode capacitance — C_D = .65 pF typ at V_R = −2V

applications

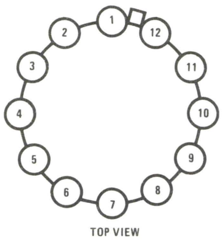
- Balanced modulators or demodulators
- Ring modulators
- High speed diode gates
- Analog switches

For applications such as balanced modulators or ring modulators where capacitive balance is important, the substrate should be returned to a DC potential which is significantly more negative (with respect to the active diodes) than the peak signal applied.

schematic and connection diagrams



Metal Can Package



Order Number LM3039H

See Package 7

absolute maximum ratings

Power Dissipation	
Any One Diode	100 mW
Total For Device	600 mW
For $T_A > 55^\circ C$	Derate Linearly 5.7 mW/°C
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Peak Inverse Voltage, PIV for: D1 – D5	5V
D6	.5V
Peak Diode to Substrate Voltage, V_{DI} for D1 – D5 (Term. 1, 4, 5, 8 or 12 to Term. 10)	+20, −1V
DC Forward Current, I_F	25 mA
Peak Recurrent Forward Current, I_f	100 mA
Peak Forward Surge Current, $I_{f\,(SURGE)}$	100 mA

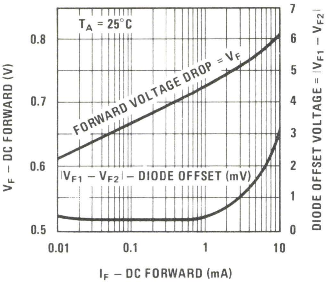
electrical characteristics

(T_A = 25°C) Characteristics apply for each diode unit, unless otherwise specified.

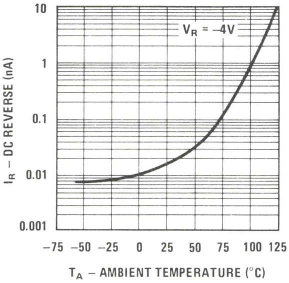
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Forward Voltage Drop (V_F)	$I_F = 50\mu A$		.65	.69	V
	1 mA		.73	.78	V
	3 mA		.76	.80	V
	10 mA		.81	.90	V
DC Reverse Breakdown Voltage ($V_{(BR)R}$)	$I_R = -10\mu A$	5	7		V
DC Reverse Breakdown Voltage Between Any Diode Unit and Substrate ($V_{(BR)R}$)	$I_R = -10\mu A$	20			V
DC Reverse (Leakage) Current (I_R)	$V_R = -4V$		.016	100	nA
DC Reverse (Leakage) Current Between Any Diode Unit and Substrate (I_R)	$V_R = -10V$		.022	100	nA
Magnitude of Diode Offset Voltage (Difference in DC Forward Voltage Drops of Any Two Diode Units) ($\lvert V_{F_1} - V_{F_2}\rvert$)	I_F = 1 mA		.5	5	mV
Temperature Coefficient of $\lvert V_{F_1} - V_{F_2}\rvert$ $\left(\frac{\Delta\lvert V_{F_1} - V_{F_2}\rvert}{\Delta T}\right)$	I_F = 1 mA		1		$\mu V/^\circ C$
Temperature Coefficient of Forward Drop $\left(\frac{\Delta V_F}{\Delta T}\right)$	I_F = 1 mA		−1.9		mV/°C
DC Forward Voltage Drop for Anode-to-Substrate Diode (D_S) (V_F)	I_F = 1 mA		.65		V
Reverse Recovery Time (t_{rr})	I_F = 10 mA, I_R = 10 mA		1		ns
Diode Resistance (R_D)	f = 1 kHz, I_F = 1 mA	25	30	45	Ω
Diode Capacitance (C_D)	$V_R = -2V$, $I_F = 0$		.65		pF
Diode-to-Substrate Capacitance (C_{DI})	$V_{DI} = +4V$, $I_F = 0$		3.2		pF

typical performance characteristics

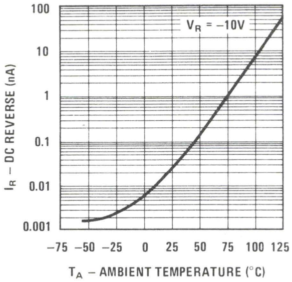
DC Forward Voltage Drop (Any Diode) and Diode Offset Voltage vs DC Forward Current



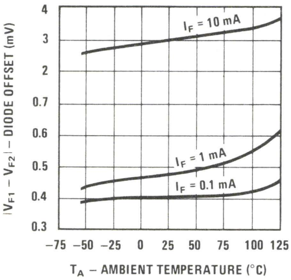
DC Reverse (Leakage) Current (Diodes 1, 2, 3, 4, 5) vs Temperature



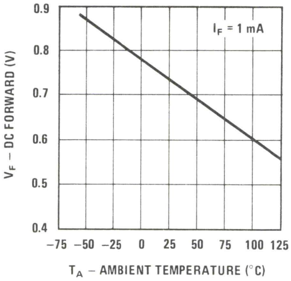
DC Reverse (Leakage) Current Between Diodes (1, 2, 3, 4, 5) and Substrate vs Temperature



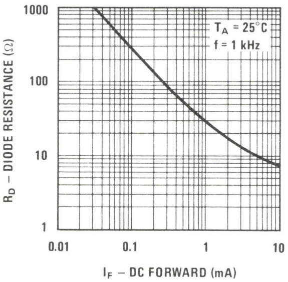
Diode Offset Voltage (Any Diode) vs Temperature



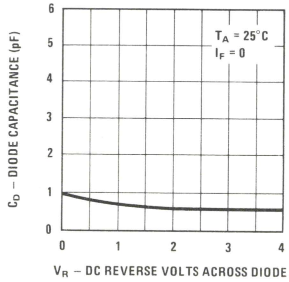
DC Forward Voltage Drop (Any Diode) vs Temperature



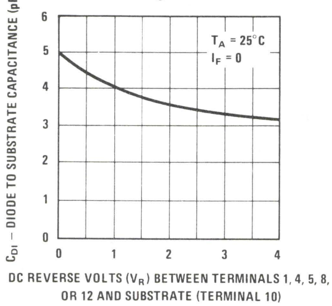
Diode Resistance (Any Diode) vs DC Forward Current



Diode Capacitance (Diodes 1, 2, 3, 4, 5) vs Reverse Voltage



Diode-to-Substrate Capacitance vs Reverse Voltage



Transistor/Diode Arrays

LM3045, LM3046, LM3086 transistor arrays

general description

The LM3045, LM3046, and LM3086 each consist of five general purpose silicon NPN transistors on a common monolithic substrate. Two of the transistors are internally connected to form a differentially-connected pair. The transistors are well suited to a wide variety of applications in low power system in the DC through VHF range. They may be used as discrete transistors in conventional circuits however, in addition, they provide the very significant inherent integrated circuit advantages of close electrical and thermal matching. The LM3045 is supplied in a 14-lead cavity dual-in-line package rated for operation over the full military temperature range. The LM3046 and LM3086 are electrically identical to the LM3045 but are supplied in a 14-lead molded dual-in-line package for applications requiring only a limited temperature range.

features

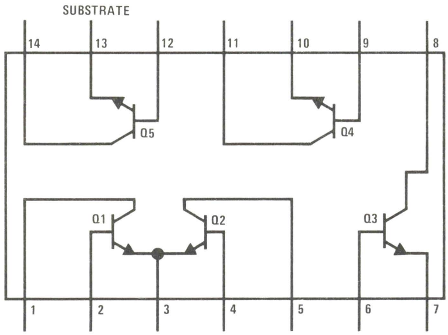
- Two matched pairs of transistors
  - V_{BE} matched ±5 mV
  - Input offset current 2μA max at I_C = 1 mA
- Five general purpose monolithic transistors
- Operation from DC to 120 MHz
- Wide operating current range
- Low noise figure 3.2 dB typ at 1 kHz
- Full military temperature range (LM3045) −55°C to +125°C

applications

- General use in all types of signal processing systems operating anywhere in the frequency range from DC to VHF
- Custom designed differential amplifiers
- Temperature compensated amplifiers

schematic and connection diagram

Dual-In-Line Package



TOP VIEW

Order Number LM3045D
See Package 1
or
Order Number LM3046N or LM3086N
See Package 22

absolute maximum ratings ($T_A = 25°C$)

	LM3045 Each Transistor	LM3045 Total Package	LM3046/LM3086 Each Transistor	LM3046/LM3086 Total Package	Units
Power Dissipation:					
$T_A = 25°C$	300	750	300	750	mW
$T_A = 25°C$ to $55°C$			300	750	mW
$T_A > 55°C$			Derate at 6.67		mW/°C
$T_A = 25°C$ to $75°C$	300	750			mW
$T_A > 75°C$	Derate at 8				mW/°C
Collector to Emitter Voltage, V_{CEO}	15		15		V
Collector to Base Voltage, V_{CBO}	20		20		V
Collector to Substrate Voltage, V_{CIO} (Note 1)	20		20		V
Emitter to Base Voltage, V_{EBO}	5		5		V
Collector Current, I_C	50		50		mA
Operating Temperature Range	−55°C to +125°C		0°C to +85°C		
Storage Temperature Range	−65°C to +150°C		−25°C to +85°C		
Lead Temperature (Soldering, 10 sec)	300		300		°C

electrical characteristics ($T_A = 25°C$ unless otherwise specified)

PARAMETER	CONDITIONS	LM3045, LM3046 MIN	LM3045, LM3046 TYP	LM3045, LM3046 MAX	LM3086 MIN	LM3086 TYP	LM3086 MAX	UNITS
Collector to Base Breakdown Voltage ($V_{(BR)CBO}$)	$I_C = 10\mu A$, $I_E = 0$	20	60		20	60		V
Collector to Emitter Breakdown Voltage ($V_{(BR)CEO}$)	$I_C = 1$ mA, $I_B = 0$	15	24		15	24		V
Collector to Substrate Breakdown Voltage ($V_{(BR)CIO}$)	$I_C = 10\mu A$, $I_{CI} = 0$	20	60		20	60		V
Emitter to Base Breakdown Voltage ($V_{(BR)EBO}$)	$I_E = 10\mu A$, $I_C = 0$	5	7		5	7		V
Collector Cutoff Current (I_{CBO})	$V_{CB} = 10V$, $I_E = 0$		.002	40		.002	100	nA
Collector Cutoff Current (I_{CEO})	$V_{CE} = 10V$, $I_B = 0$			.5			5	μA
Static Forward Current Transfer Ratio (Static Beta) (h_{FE})	$V_{CE} = 3V$ $I_C = 10$ mA		100			100		
	$V_{CE} = 3V$ $I_C = 1$ mA	40	100		40	100		
	$V_{CE} = 3V$ $I_C = 10\mu A$		54			54		
Input Offset Current for Matched Pair Q_1 and Q_2 $\|I_{O1} - I_{O2}\|$	$V_{CE} = 3V$, $I_C = 1$ mA		.3	2				μA
Base to Emitter Voltage (V_{BE})	$V_{CE} = 3V$ $I_E = 1$ mA		.715			.715		V
	$V_{CE} = 3V$ $I_E = 10$ mA		.800			.800		
Magnitude of Input Offset Voltage for Differential Pair $\|V_{BE1} - V_{BE2}\|$	$V_{CE} = 3V$, $I_C = 1$ mA		.45	5				mV
Magnitude of Input Offset Voltage for Isolated Transistors $\|V_{BE3} - V_{BE4}\|$, $\|V_{BE4} - V_{BE5}\|$, $\|V_{BE5} - V_{BE3}\|$	$V_{CE} = 3V$, $I_C = 1$ mA		.45	5				mV
Temperature Coefficient of Base to Emitter Voltage $\left(\frac{\Delta V_{BE}}{\Delta T}\right)$	$V_{CE} = 3V$, $I_C = 1$ mA		−1.9			−1.9		mV/°C
Collector to Emitter Saturation Voltage ($V_{CE(SAT)}$)	$I_B = 1$ mA, $I_C = 10$ mA		.23			.23		V
Temperature Coefficient of Input Offset Voltage $\left(\frac{\Delta V_{10}}{\Delta T}\right)$	$V_{CE} = 3V$, $I_C = 1$ mA		1.1					μV/°C

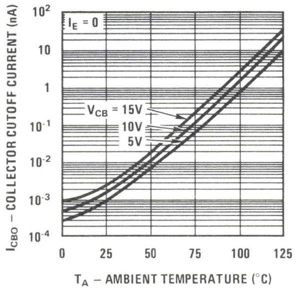
Note 1: The collector of each transistor of the LM3045, LM3046, and LM3086 is isolated from the substrate by an integral diode. The substrate (terminal 13) must be connected to the most negative point in the external circuit to maintain isolation between transistors and to provide for normal transistor action.

electrical characteristics (con't)

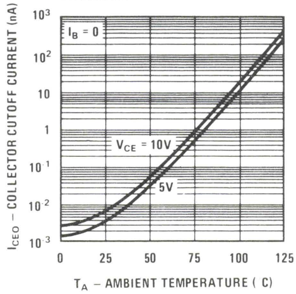
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Low Frequency Noise Figure (NF)	f = 1 kHz, V_{CE} = 3V, I_C = 100μA R_S = 1 kΩ		3.25		dB
Low Frequency, Small Signal Equivalent Circuit Characteristics:					
Forward Current Transfer Ratio (h_{fe})	f = 1 kHz, V_{CE} = 3V, I_C = 1 mA		110 (LM3045, LM3046) (LM3086)		
Short Circuit Input Impedance (h_{ie})			3.5		kΩ
Open Circuit Output Impedance (h_{oe})			15.6		μmho
Open Circuit Reverse Voltage Transfer Ratio (h_{re})			1.8×10^{-4}		
Admittance Characteristics:					
Forward Transfer Admittance (Y_{fe})	f = 1 MHz, V_{CE} = 3V, I_C = 1 mA		31 - j 1.5		
Input Admittance (Y_{ie})			0.3+j 0.04		
Output Admittance (Y_{oe})			0.001+j 0.03		
Reverse Transfer Admittance (Y_{re})			See curve		
Gain Bandwidth Product (f_T)	V_{CE} = 3V, I_C = 3 mA	300	550		
Emitter to Base Capacitance (C_{EB})	V_{EB} = 3V, I_E = 0		.6		pF
Collector to Base Capacitance (C_{CB})	V_{CB} = 3V, I_C = 0		.58		pF
Collector to Substrate Capacitance (C_{CI})	V_{CS} = 3V, I_C = 0		2.8		pF

typical performance characteristics

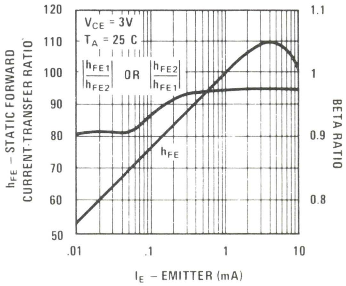
Typical Collector To Base Cutoff Current vs Ambient Temperature for Each Transistor



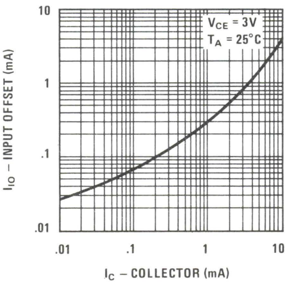
Typical Collector To Emitter Curoff Current vs Ambient Temperature for Each Transistor



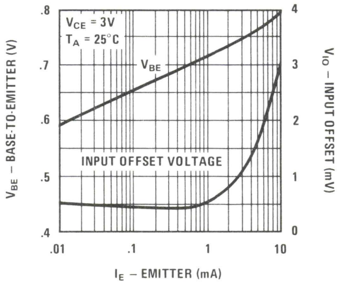
Typical Static Forward Current-Transfer Ratio and Beta Ratio for Transistors Q_1 and Q_2 vs Emitter Current



Typical Input Offset Current for Matched Transistor Pair Q_1 Q_2 vs Collector Current



Typical Static Base To Emitter Voltage Characteristic and Input Offset Voltage for Differential Pair and Paired Isolated Transistors vs Emitter Current



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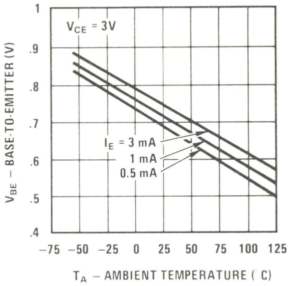
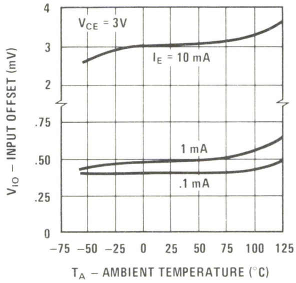
typical performance characteristics (con't)

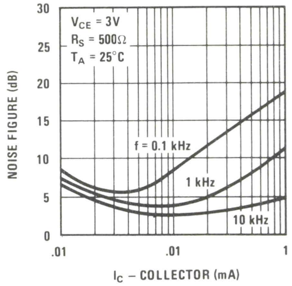
Typical Base To Emitter Voltage Characteristic for Each Transistor vs Ambient Temperature



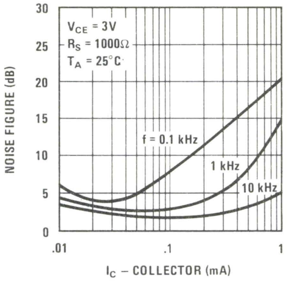
Typical Input Offset Voltage Characteristics for Differential Pair and Paired Isolated Transistors vs Ambient Temperature



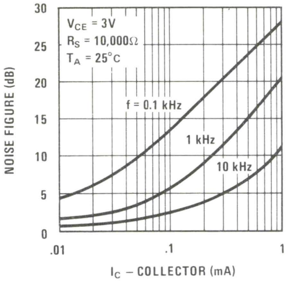
Typical Noise Figure vs Collector Current



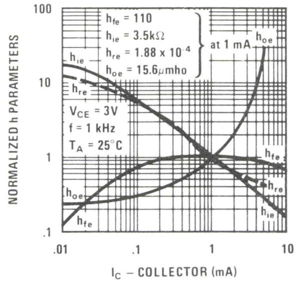
Typical Noise Figure vs Collector Current



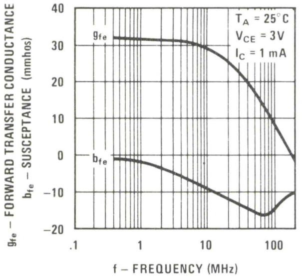
Typical Noise Figure vs Collector Current



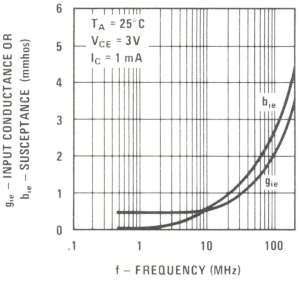
Typical Normalized Forward Current Transfer Ratio, Short Circuit Input Impedance, Open Circuit Output Impedance, and Open Circuit Reverse Voltage Transfer Ratio vs Collector Current



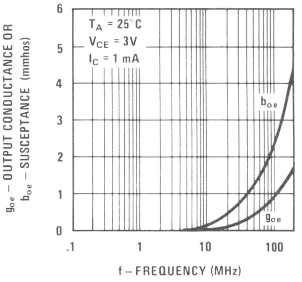
Typical Forward Transfer Admittance vs Frequency



Typical Input Admittance vs Frequency

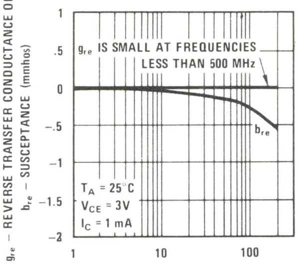


Typical Output Admittance vs Frequency

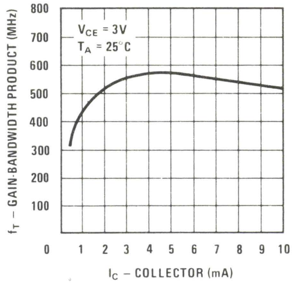


typical performance characteristics (con't)

Typical Reverse Transfer Admittance vs Frequency



Typical Gain-Bandwidth Product vs Collector Current



6

Analog Switches

AH0014/AH0014C* DPDT, AH0015/AH0015C quad SPST, AH0019/AH0019C* dual DPST-TTL/DTL compatible MOS analog switches

general description

This series of TTL/DTL compatible MOS analog switches feature high speed with internal level shifting and driving. The package contains two monolithic integrated circuit chips: the MOS analog chip is similar to the MM450 type which consists of four MOS analog switch transistors; the second chip is a bipolar I.C. gate and level shifter. The series is available in both hermetic dual-in-line package and flatpack.

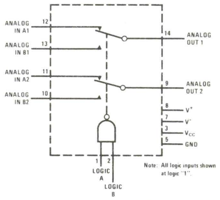
features

- Large analog voltage switching ±10V
- Fast switching speed 500 ns
- Operation over wide range of power supplies
- Low ON resistance 200Ω
- High OFF resistance 10^{11}Ω
- Fully compatible with DTL or TTL logic
- Includes gating and level shifting

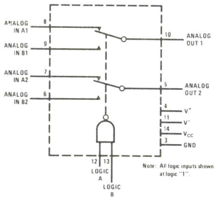
These switches are particularly suited for use in both military and industrial applications such as commutators in data acquisition systems, multiplexers, A/D and D/A converters, long time constant integrators, sample and hold circuits, modulators/demodulators, and other analog signal switching applications. For information on other National analog switches and analog interface elements, see listing on last page.

The AH0014, AH0015 and AH0019 are specified for operation over the –55°C to +125°C military temperature range. The AH0014C, AH0015C and AH0019C are specified for operation over the –25°C to +85°C temperature range.

block and connection diagrams

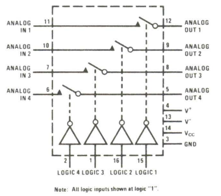


Order Number AH0014F or AH0014CF
See Package 4



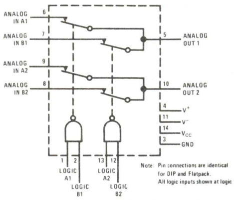
Order Number AH0014D or AH0014CD
See Package 1

Quad SPST



Order Number AH0015D or AH0015CD
See Package 2

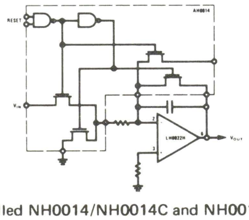
Dual DPST



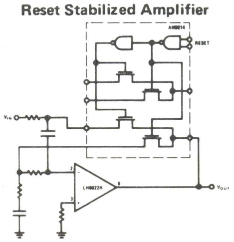
Order Number AH0019F or AH0019CF
See Package 4
Order Number AH0019D or AH0019CD
See Package 1

typical applications

Integrator



Reset Stabilized Amplifier



*Previously called NH0014/NH0014C and NH0019/NH0019C

7

absolute maximum ratings

V_{CC} Supply Voltage	7.0V
V^- Supply Voltage	−30V
V^+ Supply Voltage	+30V
V^+/V^- Voltage Differential	40V
Logic Input Voltage	5.5V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
AH0014, AH0015, AH0019	−55°C to +125°C
AH0014C, AH0015C, AH0019C	−25°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 1 and 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	V_{CC} = 4.5V		2.0			V
Logical "0" Input Voltage	V_{CC} = 4.5V				0.8	V
Logical "1" Input Current	V_{CC} = 5.5V	V_{IN} = 2.4V			5	μA
Logical "1" Input Current	V_{CC} = 5.5V	V_{IN} = 5.5V			1	mA
Logical "0" Input Current	V_{CC} = 5.5V	V_{IN} = 0.4V		0.2	0.4	mA
Power Supply Current Logical "1" Input – each gate (Note 3)	V_{CC} = 5.5V	V_{IN} = 4.5V		0.85	1.6	mA
Power Supply Current Logical "0" Input – each gate (Note 3)	V_{CC} = 5.5V	V_{IN} = 0V				
AH0014, AH0014C				1.5	3.0	mA
AH0015, AH0015C				0.22	0.41	mA
AH0019, AH0019C				0.22	0.41	mA
Analog Switch ON Resistance – each gate	V_{IN} (Analog) = +10V			75	200	Ω
	V_{IN} (Analog) = −10V			150	600	Ω
Analog Switch OFF Resistance				10^{11}		Ω
Analog Switch Input Leakage Current – each input (Note 4)	V_{IN} = −10V					
AH0014, AH0015, AH0019	T_A = 25°C			25	200	pA
	T_A = 125°C			25	200	nA
AH0014C, AH0015C, AH0019C	T_A = 25°C			0.1	10	nA
	T_A = 70°C			30	100	nA
Analog Switch Output Leakage Current – each output (Note 4)	V_{OUT} = −10V					
AH0014, AH0015, AH0019	T_A = 25°C			40	400	pA
	T_A = 125°C			40	400	nA
AH0014C, AH0015C, AH0019C	T_A = 25°C			0.05	10	nA
	T_A = 70°C			4	50	nA
Analog Input (Drain) Capacitance	1 MHz @ Zero Bias			8	10	pF
Output Source Capacitance	1 MHz @ Zero Bias			11	13	pF
Analog Turn-OFF Time – t_{OFF}	See test circuit; T_A = 25°C			400	500	ns
Analog Turn-ON Time – t_{ON}	See test circuit; T_A = 25°C					
AH0014, AH0014C				350	425	ns
AH0015, AH0015C				100	150	ns
AH0019, AH0019C				100	150	ns

Note 1: Min/max limits apply across the guaranteed temperature range of −55°C to +125°C for AH0014, AH0015, AH0019 and −25°C to +85°C for AH0014C, AH0015C, AH0019C. V^- = −20V. V^+ = +10V and an analog test current of 1 mA unless otherwise specified.

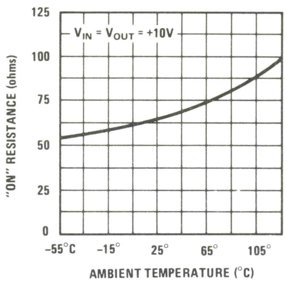
Note 2: All typical values are measured at T_A = 25°C with V_{CC} = 5.0V. V^+ = +10V, V^- = −22V.

Note 3: Current measured is drawn from V_{CC} supply.

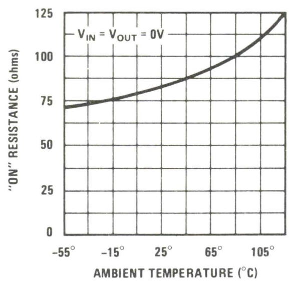
Note 4: All analog switch pins except measurement pin are tied to V^+.

analog switch characteristics (Note 2)

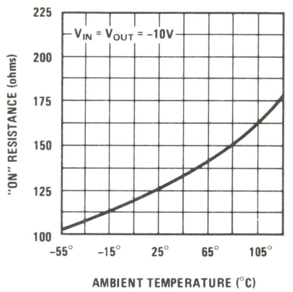
RON vs Temperature



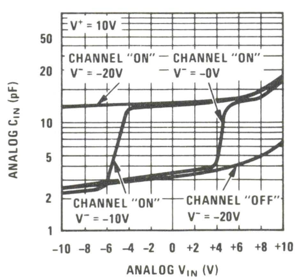
RON vs Temperature



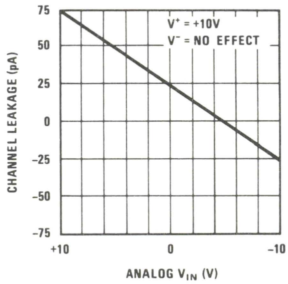
RON vs Temperature



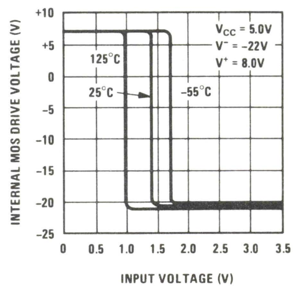
CIN vs VIN



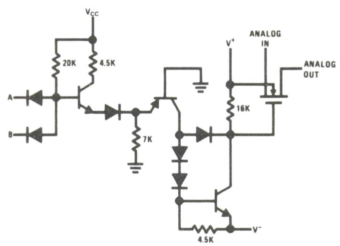
Leakage vs VIN (Channel "OFF")



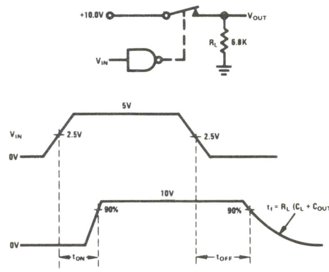
Driver Gate VIN vs VOUT



Schematic (Single Driver Gate and MOS Switch Shown)

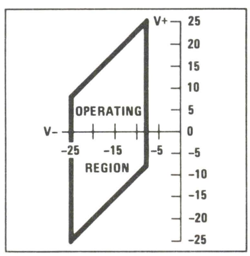


Analog Switching Time Test Circuit



selecting power supply voltage

The graph shows the boundary conditions which must be used for proper operation of the unit. The range of operation for power supply V^- is shown on the X axis. It must be between –25V and –8V. The allowable range for power supply V^+ is governed by supply V^-. With a value chosen for V^-, V^+ may be selected as any value along a vertical line passing through the V^- value and terminated by the boundaries of the operating region. A voltage difference between power supplies of at least 5V should be maintained for adequate signal swing.



7

Analog Switches

AH0120/AH0130/AH0140/AH0150/AH0160 series analog switches

general description

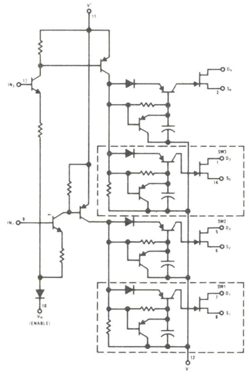
The AH0100 series represents a complete family of junction FET analog switches. The inherent flexibility of the family allows the designer to tailor the device selection to the particular application. Switch configurations available include dual DPST, dual SPST, DPDT, and SPDT. $r_{ds(ON)}$ ranges from 10 ohms through 100 ohms. The series is available in both 14 lead flat pack and 14 lead cavity DIP. Important design features include:

- TTL/DTL and RTL compatible logic inputs
- Up to 20V p-p analog input signal
- $r_{ds(ON)}$ less than 10Ω (AH0140, AH0141, AH0145, AH0146)
- Analog signals in excess of 1 MHz
- "OFF" power less than 1 mW
- Gate to drain bleed resistors eliminated
- Fast switching, t_{ON} is typically .4 μs, t_{OFF} is 1.0 μs
- Operation from standard op amp supply voltages, ±15V, available (AH0150/AH0160 series)
- Pin compatible with the popular DG 100 series.

The AH0100 series is designed to fulfill a wide variety of analog switching applications including commutators, multiplexers, D/A converters, sample and hold circuits, and modulators/demodulators. The AH0100 series is guaranteed over the temperature range −55°C to +125°C; whereas, the AH0100C series is guaranteed over the temperature range −25°C to +85°C.

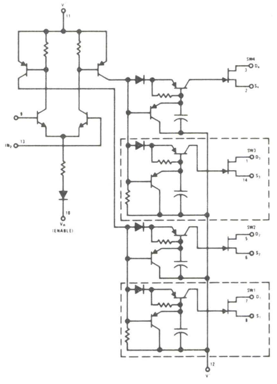
schematic diagrams

DUAL DPST and DUAL SPST



Note: Dotted line portions are not applicable to the dual SPST.

DPDT (diff.) and SPDT (diff.)

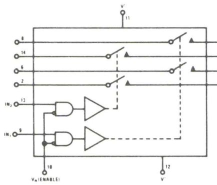


Note: Dotted line portions are not applicable to the SPDT (differential).

logic and connection diagrams

Order any of the devices below using the part number with a D or F suffix. See Packages 1 and 4.

DUAL DPST



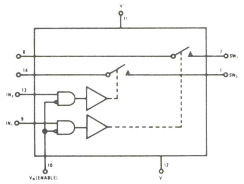
HIGH LEVEL (±10V)

AH0140 (10Ω)
AH0129 (30Ω)
AH0126 (80Ω)

MEDIUM LEVEL (±7.5V)

AH0153 (15Ω)
AH0154 (50Ω)

DUAL SPST



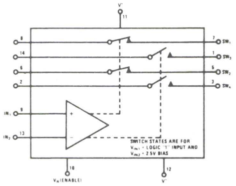
HIGH LEVEL (±10V)

AH0141 (10Ω)
AH0133 (30Ω)
AH0134 (80Ω)

MEDIUM LEVEL (±7.5V)

AH0151 (15Ω)
AH0152 (50Ω)

DPDT (Diff)



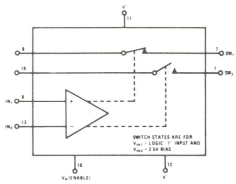
HIGH LEVEL (±10V)

AH0145 (10Ω)
AH0139 (30Ω)
AH0142 (80Ω)

MEDIUM LEVEL (±7.5)

AH0163 (15Ω)
AH0164 (50Ω)

SPDT (Diff)



HIGH LEVEL (±10V)

AH0146 (10Ω)
AH0144 (30Ω)
AH0143 (80Ω)

MEDIUM LEVEL (±7.5V)

AH0161 (15Ω)
AH0162 (50Ω)

absolute maximum ratings

		High Level	Medium Level
Total Supply Voltage ($V^+ - V^-$)		36V	34V
Analog Signal Voltage ($V^+ - V_A$ or $V_A - V^-$)		30V	25V
Positive Supply Voltage to Reference ($V^+ - V_R$)		25V	25V
Negative Supply Voltage to Reference ($V_R - V^-$)		22V	22V
Positive Supply Voltage to Input ($V^+ - V_{IN}$)		25V	25V
Input Voltage to Reference ($V_{IN} - V_R$)		±6V	±6V
Differential Input Voltage ($V_{IN} - V_{IN2}$)		±6V	±6V
Input Current, Any Terminal		30 mA	30 mA
Power Dissipation		See Curve	
Operating Temperature Range	AH0100 Series	−55°C to +125°C	
	AH0100C Series	−25°C to +85°C	
Storage Temperature Range		−65°C to +150°C	
Lead Temperature (Soldering, 10 sec)		300°C	

electrical characteristics for "HIGH LEVEL" Switches (Note 1)

PARAMETER	SYMBOL	DEVICE TYPE DUAL DPST	DUAL SPST	DPDT (DIFF)	SPDT (DIFF)	CONDITIONS $V^+ = 12.0V$, $V^- = -18.0V$, $V_R = 0.0V$		LIMITS TYP	MAX	UNITS
Logic "1" Input Current	$I_{IN(ON)}$	All Circuits				Note 2	$T_A = 25°C$	2.0	60	μA
							Over Temp. Range		120	μA
Logic "0" Input Current	$I_{IN(OFF)}$	All Circuits				Note 2	$T_A = 25°C$	.01	.1	μA
							Over Temp. Range		2.0	μA
Positive Supply Current Switch ON	$I^+_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	2.2	3.0	mA
							Over Temp. Range		3.3	mA
Negative Supply Current Switch ON	$I^-_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	−1.0	−1.8	mA
							Over Temp. Range		−2.0	mA
Reference Input (Enable) ON Current	$I_{R(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	−1.0	−1.4	mA
							Over Temp. Range		−1.6	mA
Positive Supply Current Switch OFF	$I^+_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	1.0	10	μA
							Over Temp. Range		25	μA
Negative Supply Current Switch OFF	$I^-_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	−1.0	−10	μA
							Over Temp. Range		−25	μA
Reference Input (Enable) OFF Current	$I_{R(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	−1.0	−10	μA
							Over Temp. Range		−25	μA
Switch ON Resistance	$r_{ds(ON)}$	AH0126	AH0134	AH0142	AH0143	$V_D = 10V$	$T_A = 25°C$	45	80	Ω
						$I_D = 1$ mA	Over Temp. Range		150	Ω
Switch ON Resistance	$r_{ds(ON)}$	AH0129	AH0133	AH0139	AH0144	$V_D = 10V$	$T_A = 25°C$	25	30	Ω
						$I_D = 1$ mA	Over Temp. Range		60	Ω
Switch ON Resistance	$r_{ds(ON)}$	AH0140	AH0141	AH0145	AH0146	$V_D = 10V$	$T_A = 25°C$	8	10	Ω
						$I_F = 1$ mA	Over Temp. Range		20	Ω
Driver Leakage Current	$(I_D + I_S)_{ON}$	All Circuits				$V_D = V_S = -10V$	$T_A = 25°C$	.01	1	nA
							Over Temp. Range		100	nA
Switch Leakage Current	$I_{S(OFF)}$ OR $I_{D(OFF)}$	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	$V_{DS} = \pm 20V$	$T_A = 25°C$	0.8	1	nA
							Over Temp. Range		100	nA
Switch Leakage Current	$I_{S(OFF)}$ OR $I_{D(OFF)}$	AH0140	AH0141	AH0145	AH0146	$V_{DS} = \pm 20V$	$T_A = 25°C$	4	10	nA
							Over Temp. Range		1.0	μA
Switch Turn-ON Time	t_{ON}	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	See Test Circuit $V_A = \pm 10V$ $T_A = 25°C$		0.5	0.8	μs
Switch Turn-ON Time	t_{ON}	AH0140	AH0141	AH0145	AH0146	See Test Circuit $V_A = \pm 10V$ $T_A = 25°C$		0.8	1.0	μs
Switch Turn-OFF Time	t_{OFF}	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	See Test Circuit $V_A = \pm 10V$ $T_A = 25°C$		0.9	1.6	μs
Switch Turn-OFF Time	t_{OFF}	AH0140	AH0141	AH0145	AH0146	See Test Circuit $V_A = \pm 10V$ $T_A = 25°C$		1.1	2.5	μs

Note 1: Unless otherwise specified these limits apply for −55°C to +125°C for the AH0100 series and −25°C to +85°C for the AH0100C series. All typical values are for $T_A = 25°C$.

Note 2: For the DPST and Dual DPST, the ON condition is for $V_{IN} = 2.5V$; the OFF condition is for $V_{IN} = 0.8V$. For the differential switches and SW1 and 2 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 3.0V$. For SW3 and 4 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 2.0V$.

electrical characteristics for "MEDIUM LEVEL" Switches (Note 1)

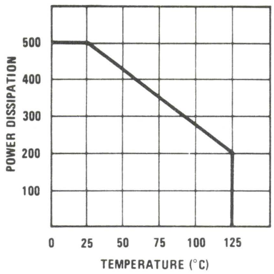
PARAMETER	SYMBOL	DEVICE TYPE DUAL DPST	DUAL SPST	DUAL DPDT	SPDT (DIFF)	CONDITIONS $V^+ = +15.0V, V^- = -15V, V_R = 0V$		LIMITS TYP	MAX	UNITS
Logic "1" Input Current	$I_{IN(ON)}$	All Circuits				Note 2	$T_A = 25°C$	20	60	μA
							Over Temp. Range		120	μA
Logic "0" Input Current	$I_{IN(OFF)}$	All Circuits				Note 2	$T_A = 25°C$	.01	0.1	μA
							Over Temp. Range		2	μA
Positive Supply Current Switch ON	$I^+_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	2.2	3.0	mA
							Over Temp. Range		3.3	mA
Negative Supply Current Switch ON	$I^-_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	-1.0	-1.8	mA
							Over Temp. Range		-2.0	mA
Reference Input (Enable) ON Current	$I_{R(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25°C$	-1.0	-1.4	mA
							Over Temp. Range		-1.6	mA
Positive Supply Current Switch OFF	$I^+_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	1.0	10	μA
							Over Temp. Range		25	μA
Negative Supply Current Switch OFF	$I^-_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	-1.0	-10	μA
							Over Temp. Range		-25	μA
Reference Input (Enable) OFF Current	$I_{R(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25°C$	-1.0	-10	μA
							Over Temp. Range		-25	μA
Switch ON Resistance	$r_{ds(ON)}$	AH0153	AH0151	AH0163	AH0161	$V_D = 7.5V$, $I_D = 1 mA$	$T_A = 25°C$	10	15	Ω
							Over Temp. Range		30	Ω
Switch ON Resistance	$r_{ds(ON)}$	AH0154	AH0152	AH0164	AH0162	$V_D = 7.5V$, $I_D = 1 mA$	$T_A = 25°C$	45	50	Ω
							Over Temp. Range		100	Ω
Driver Leakage Current	$(I_D + I_S)_{ON}$	All Circuits				$V_D = V_S = -7.5V$	$T_A = 25°C$	.01	2	nA
							Over Temp. Range		500	nA
Switch Leakage Current	$I_{D(OFF)}$ OR $I_{S(OFF)}$	AH0153	AH0151	AH0163	AH0161	$V_{DS} = \pm 15V$	$T_A = 25°C$	5	10	nA
							Over Temp. Range		1.0	μA
Switch Leakage Current	$I_{D(OFF)}$ OR $I_{S(OFF)}$	AH0154	AH0152	AH0164	AH0162	$V_{DS} = \pm 15.0V$	$T_A = 25°C$	1.0	2.0	nA
							Over Temp. Range		200	nA
Switch Turn-ON Time	t_{ON}	AH0153	AH0151	AH0163	AH0161	See Test Circuit $V_A = \pm 7.5V$ $T_A = 25°C$		0.8	1.0	μs
Switch Turn-ON Time	t_{ON}	AH0154	AH0152	AH0164	AH0162	See Test Circuit $V_A = \pm 7.5V$ $T_A = 25°C$		0.5	0.8	μs
Switch Turn-OFF Time	t_{OFF}	AH0153	AH0151	AH0163	AH0161	See Test Circuit $V_A = \pm 7.5V$ $T_A = 25°C$		1.1	2.5	μs
Switch Turn-OFF Time	t_{OFF}	AH0154	AH0152	AH0164	AH0162	See Test Circuit $V_A = \pm 7.5V$ $T_A = 25°C$		0.9	1.5	μs

Note 1: Unless otherwise specified, these limits apply for −55°C to +125°C for the AH0100 series and −25°C to +85°C for the AH0100C series. All typical values are for $T_A = 25°C$.

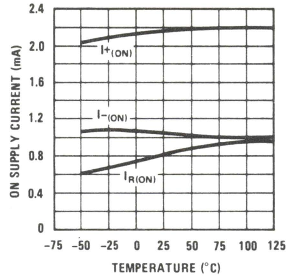
Note 2: For the DPST and Dual DPST, the ON condition is for $V_{IN} = 2.5V$; the OFF condition is for $V_{IN} = 0.8V$. For the differential switches and SW1 and 2 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 3.0V$. For SW3 and 4 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 2.0V$.

typical performance characteristics

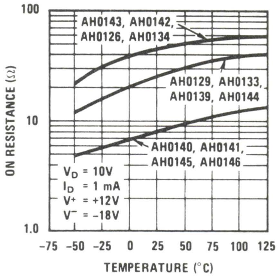
Power Dissipation vs Temperature



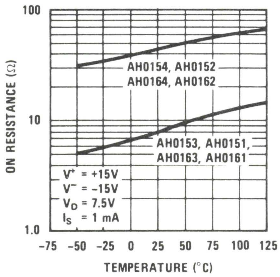
ON Supply Current vs Temperature



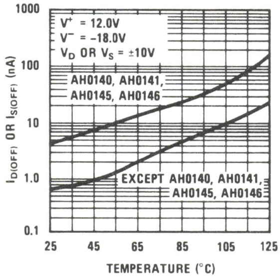
$r_{ds(ON)}$ vs Temperature AH0120 thru AH0140 Series



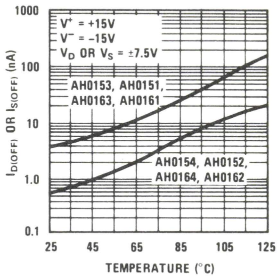
$r_{ds(ON)}$ vs Temperature AH0150/AH0160 Series



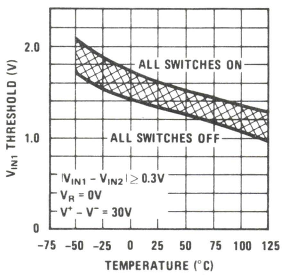
Leakage Current vs Temperature AH0120, AH0130, & AH0140



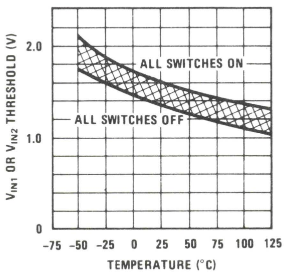
Leakage Current vs Temperature AH0150 & AH0160



Single Ended Switch Input Threshold vs Temperature

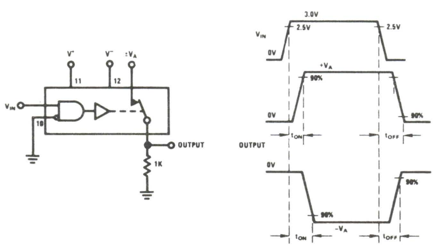


Differential Switch Input Threshold vs Temperature

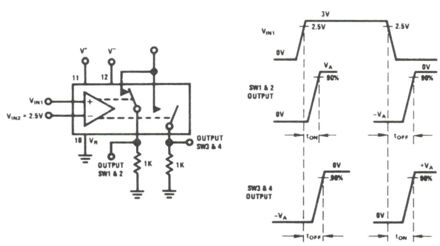


switching time test circuits

Single Ended Input



Differential Input



applications information

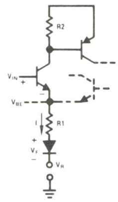
1. INPUT LOGIC COMPATIBILITY

A. Voltage Considerations

In general, the AH0100 series is compatible with most DTL, TTL, and RTL logic families. The ON-input threshold is determined by the V_{BE} of the input transistor plus the V_f of the diode in the emitter leg, plus I x R_1, plus V_R. At room temperature and V_R = 0V, the nominal ON threshold is: 0.7V + 0.7V + 0.2V, = 1.6V. Over temperature and manufacturing tolerances, the threshold may be as high as 2.5V and as low as 0.8V. The rules for proper operation are:

$V_{IN} - V_R \geq 2.5V$ All switches ON

$V_{IN} - V_R \leq 0.8V$ All switches OFF



B. Input Current Considerations

$I_{IN(ON)}$, the current drawn by the driver with V_{IN} = 2.5V is typically 20 μA at 25°C and is guaranteed less than 120 μA over temperature. DTL, such as the DM930 series can supply 180 μA at logic "1" voltages in excess of 2.5V. TTL output levels are comparable at 400 μA. The DTL and TTL can drive the AH0100 series directly. However, at low temperature, DC noise margin in the logic "1" state is eroded with DTL. A pull-up resistor of 10 kΩ is recommended when using DTL over military temperature range.

If more than one driver is to be driven by a DM930 series (6K) gate, an external pull-up resistor should be added. The value is given by:

$$R_P = \frac{11}{N-1} \text{ for } N > 2$$

where:

R_P = value of the pull-up resistor in kΩ

N = number of drivers.

C. Input Slew Rate

The slew rate of the logic input must be in excess of 0.3V/μs in order to assure proper operation of the analog switch. DTL, TTL, and RTL output rise times are far in excess of the minimum slew rate requirements. Discrete logic designs, however, should include consideration of input rise time.

2. ENABLE CONTROL

The application of a positive signal at the V_R terminal will open all switches. The V_R (ENABLE) signal must be capable of rising to within 0.8V of $V_{IN(ON)}$ in the OFF state and of sinking $I_{R(ON)}$ milliamps in the ON state (at $V_{IN(ON)} - V_R >$ 2.5V). The V_R terminal can be driven from most TTL and DTL gates.

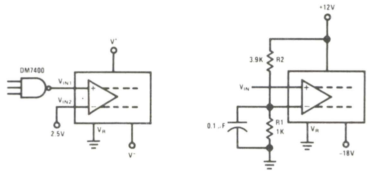
3. DIFFERENTIAL INPUT CONSIDERATIONS

The differential switch driver is essentially a differential amplifier. The input requirements for proper operation are:

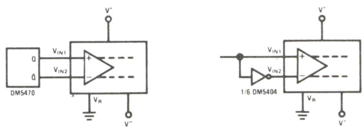
$$|V_{IN1} - V_{IN2}| \geq 0.3V$$

$$2.5 \leq (V_{IN1} \text{ or } V_{IN2}) - V_R \leq 5V$$

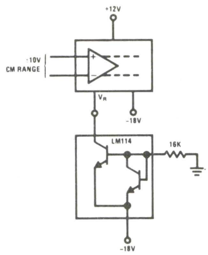
The differential driver may be furnished by a DC level as shown below. The level may be derived from a voltage divider to V^+ or the 5V V_{CC} of the DTL logic. In order to assure proper operation, the divider should be "stiff" with respect to I_{IN2}. Bypassing R1 with a 0.1 μF disc capacitor will prevent degradation of t_{ON} and t_{OFF}.



Alternatively, the differential driver may be driven from a TTL flip-flop or inverter.



Connection of a 1 mA current source between V_R and V^- will allow operation over a ±10V common mode range. Differential input voltage must be less than the 6V breakdown, and input threshold of 2.5V and 300mV differential overdrive still prevail.



4. ANALOG VOLTAGE CONSIDERATIONS

The rules for operating the AH0100 series at supply voltages other than those specified essentially breakdown into OFF and ON considerations. The OFF considerations are dictated by the maximum negative swing of the analog signal and the pinch off of the JFET switch. In the OFF state, the gate of the FET is at $V^- + V_{BE} + V_{SAT}$ or about 1.0V above the V^- potential. The maximum V_P of the FET switches is 7V. The most negative analog voltage, V_A, swing which can be accomodated for any given supply voltage is:

$$|V_A| \leq |V^-| - V_P - V_{BE} - V_{SAT} \text{ or}$$

$$|V_A| \leq |V^-| - 8.0 \text{ or } |V^-| \geq |V_A| + 8.0V$$

For the standard high level switches, $V_A \leq |-18| + 8 = -10V$. The value for V^+ is dictated by the maximum positive swing of the analog input voltage. Essentially the collector to base junction of the turn-on PNP must remain reversed biased for all positive value of analog input voltage. The base of the PNP is at $V^+ - V_{SAT} - V_{BE}$ or $V^+ - 1.0V$. The PNP's collector base junction should have at least 1.0V reverse bias. Hence, the most positive analog voltage swing which may be accommodated for a given value of V^+ is:

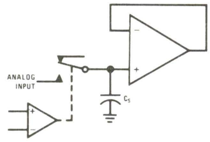
$$V_A \leq V^+ - V_{SAT} - V_{BE} - 1.0V \text{ or}$$

$$V_A \leq V^+ - 2.0V \text{ or } V^+ \geq V_A + 2.0V$$

For the standard high level switches, $V_A = 12 - 2.0V = +10V$.

5. SWITCHING TRANSIENTS

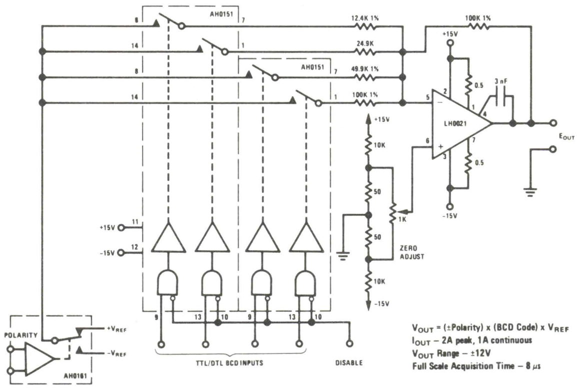
Due to charge stored in the gate-to-source and gate-to-drain capacitances of the FET switch, transients may appear in the output during switching. This is particularly true during the OFF to ON transition. The magnitude and duration of the transient may be minimized by making source and load impedance levels as small as practical.



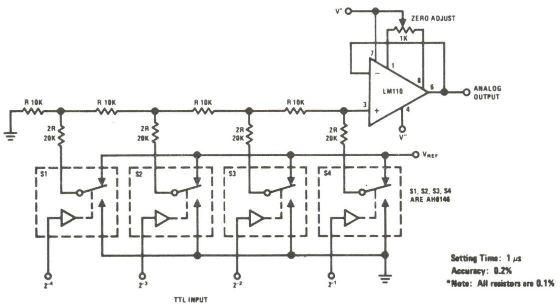
Furthermore, transients may be minimized by operating the switches in the differential mode; i.e., the charge delivered to the load during the ON to OFF transition is, to a large extent, cancelled by the OFF to ON transition.

typical applications

Programmable One Amp Power Supply

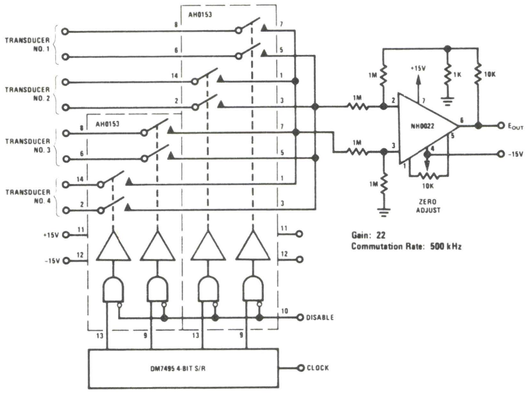


Four to Ten Bit D to A Converter (4 Bits Shown)



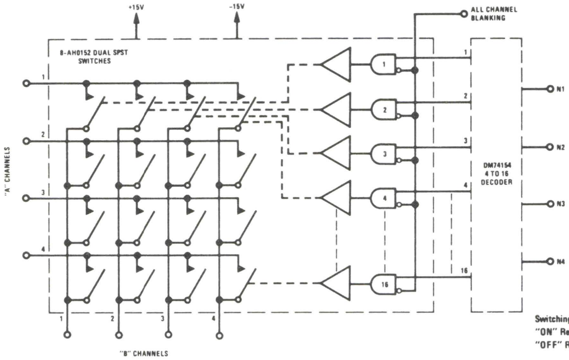
typical applications (con't)

Four Channel Differential Transducer Commutator



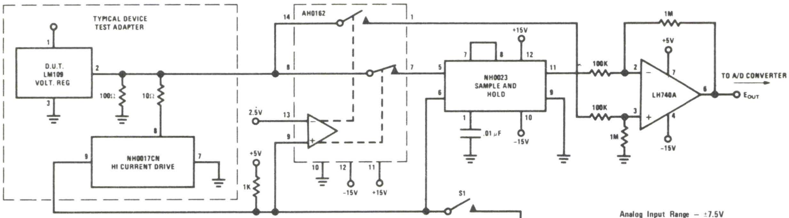
Gain: 22
Commutation Rate: 500 kHz

4 x 4 Cross Point Analog Switch



Switching Time – 800 ns
"ON" Resistance – 45Ω
"OFF" Resistance – 10^{10}Ω

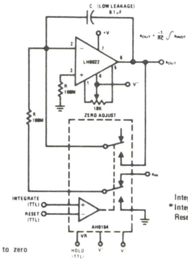
Delta Measurement System for Automatic Linear Circuit Tester



Note: S1 must be open for 50μs min to take first reading with I_L = 50 mA. Second reading is taken with S2 closed. With S1 and other set-up forcing functions under computer control, system will measure line and load regulation on voltage regulators, voltage gain, offset current, CMRR and PSRR on op amps as well as other circuits requiring measurement of the change of a parameter with the change of a forcing function.

Analog Input Range – ±7.5V
E_{OUT} = 10x (Analog Input 2 – Analog Input 1)
Error Rate – 0.01% F.S./sec

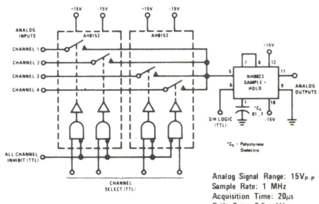
Precision Long Time Constant Integrator with Reset



Integration Internal = 10 sec
*Integration Error = 100μV
Reset Time: 30μs

*Note: V_{OS} adjusted to zero

Four Channel Commutator



Analog Signal Range: $15V_{P-P}$
Sample Rate: 1 MHz
Acquisition Time: 20μs
Drift Rate: 0.5 mV/sec

Analog Switches

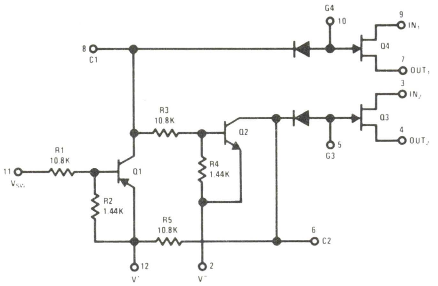
AH2114/AH2114C DPST analog switch general description

The AH2114 is a DPST analog switch circuit comprised of two junction FET switches and their associated driver. The AH2114 is designed to fulfill a wide variety of high level analog switching applications including multiplexers, A to D Converters, integrators, and choppers. Design features include:

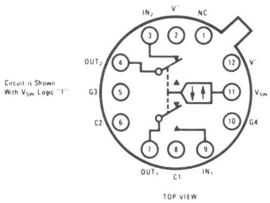
- Low ON resistance, typically 75Ω
- High OFF resistance, typically 10^{11}Ω
- Large output voltage swing, typically ±10V
- Powered from standard op-amp supply voltages of ±15V
- Input signals in excess of 1 MHz
- Turn-ON and turn-OFF times typically 1 μs

The AH2114 is guaranteed over the temperature range −55°C to +125°C whereas the AH2114C is guaranteed over the temperature range 0°C to +85°C.

schematic and connection diagrams



Metal Can Package



Order Number AH2114G or AH2114CG
See Package 6A

ac test circuit and waveforms

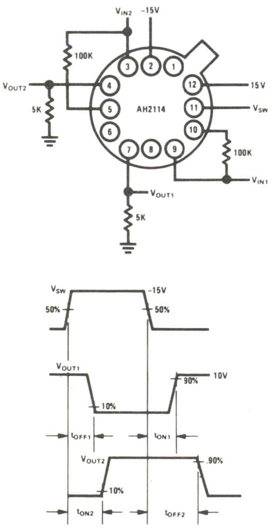


FIGURE 1.

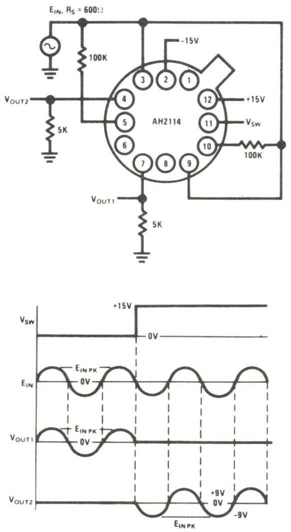


FIGURE 2.

absolute maximum ratings

Vplus Supply Voltage	+25V
Vminus Supply Voltage	−25V
Vplus−Vminus Differential Voltage	40V
Logic Input Voltage	25V
Power Dissipation (Note 3)	1.36W
Operating Temperature Range	
AH2114	−55°C to +125°C
AH2114C	0°C to +85°C
Storage Temperature Range	−65°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 1 and 2)

PARAMETER	CONDITIONS	AH2114			AH2114C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Static Drain-Source "On" Resistance	I_D = 1.0 mA, V_{GS} = 0V, T_A = 25°C		75	100		75	125	Ω
	I_D = 1.0 mA, V_{GS} = 0V			150			160	Ω
Drain-Gate Leakage Current	V_{DS} = 20V, V_{GS} = −7V, T_A = 25°C		0.2	1.0		0.2	5.0	nA
				60			60	nA
FET Gate-Source Breakdown Voltage	I_G = 1.0 μA V_{DS} = 0V	35			35			V
Drain-Gate Capacitance	V_{DG} = 20V, I_S = 0 f = 1.0 MHz, T_A = 25°C		4.0	5.0		4.0	5.0	pF
Source-Gate Capacitance	V_{DG} = 20V, I_D = 0 f = 1.0 MHz, T_A = 25°C		4.0	5.0		4.0	5.0	pF
Input 1 Turn-ON Time	V_{IN1} = 10V, T_A = 25°C (See Figure 1)		35	60		35	60	ns
Input 2 Turn-ON Time	V_{IN2} = 10V, T_A = 25°C (See Figure 1)		1.2	1.5		1.2	1.2	μs
Input 1 Turn-OFF Time	V_{IN1} = 10V, T_A = 25°C (See Figure 1)		0.6	0.75		0.6	0.75	μs
Input 2 Turn-OFF Time	V_{IN2} = 10V, T_A = 25°C (See Figure 1)		50	80		50	80	ns
DC Voltage Range	T_A = 25°C (See Figure 2)	±9.0	±10.0		±9.0	±10.0		V
AC Voltage Range	T_A = 25°C (See Figure 2)	±9.0	±10.0		±9.0	±10.0		V

Note 1: Unless otherwise specified these specifications apply for pin 12 connected to +15V, pin 2 connected to −15V, −55°C to 125°C for the AH2114, and 0°C to 85°C for the AH2114C.

Note 2: All typical values are for T_A = 25°C.

Note 3: Derate linearly at 100°C/W above 25°C.

Analog Switches

AH5009 series low cost analog current switches

general description

The AH5009 series is a versatile family of analog switches designed to economically fulfill a wide variety of multiplexing and analog switching applications.

Even numbered switches (AH5010, AH5012, AH5014, etc.,) may be driven directly from standard (5V) TTL; whereas the odd numbered switches (AH5009, AH5011, AH5013, etc.,) are intended for applications utilizing open-collector (15V) structures.

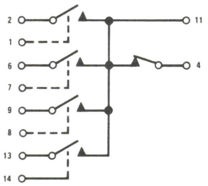
features

- Large analog signal range ±10V peak
- Excellent isolation between channels 80 dB at 1 kHz
- Very low leakage 50 pA
- High switching speed 150 ns
- Low on resistance 100Ω
- Interfaces with standard TTL

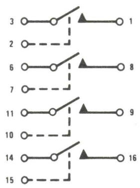
functional and schematic diagrams

(See additional types on page 6.)

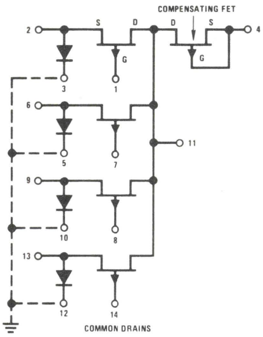
MUX Switches
(4 channel version shown)



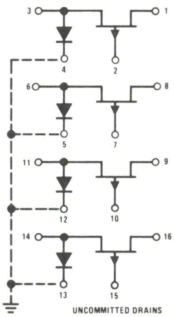
SPST Switches
(quad version shown)



MUX Switches
(4 channel version shown)

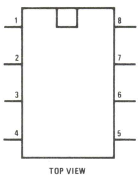


SPST Switches
(quad version shown)



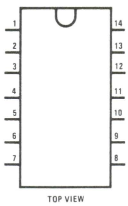
connection diagrams

Dual-In-Line Package



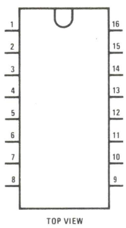
Order Number:
AH5017CN
AH5018CN
AH5019CN
AH5020CN
AH5021CN
AH5022CN
AH5023CN
AH5024CN
See Package 20

Dual-In-Line Package



Order Number:
AH5009CN
AH5010CN
AH5013CN
AH5014CN
See Package 22

Dual-In-Line Package



Order Number:
AH5011CN
AH5012CN
AH5015CN
AH5016CN
See Package 23

absolute maximum ratings

Input Voltage (V_{IN})	±30V
Positive Analog Signal Voltage (V_A)	30V
Negative Analog Signal Voltage (V_A)	−15V
Diode Current	10 mA
Drain Current (I_D)	30 mA
Power Dissipation (see graph)	500 mW
Operating Temperature Range	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C

electrical characteristics (each channel)

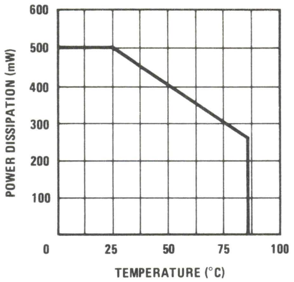
PARAMETER (Note 2)	CIRCUIT TYPE	CONDITIONS (Note 1)	TYP	MAX	UNITS
Input Current "ON" ($I_{IN(ON)}$)	All	V_{IN} = 0V, I_D = 2 mA, T_A = 25°C	.01	.1	μA
		V_{IN} = 0V, I_D = 2 mA		100	μA
Input Current "OFF" ($I_{IN(OFF)}$)	5VTTL	V_{IN} = 4.5V, V_A = ±10V, T_A = 25°C	.04	.2	nA
		V_{IN} = 4.5V, V_A = ±10V		10	nA
Input Current "OFF" ($I_{IN(OFF)}$)	15VTTL	V_{IN} = 11V, V_A = ±10V, T_A = 25°C	.04	.2	nA
				10	nA
Channel Control Voltage "ON" ($V_{IN(ON)}$)	5VTTL	V_A = ±10V, I_D = 1 mA		.5	V
	15VTTL	V_A = ±10V, I_D = 1 mA		1.5	V
Channel Control Voltage "OFF" ($V_{IN(OFF)}$)	5VTTL	V_A = ±10V		4.5	V
	15VTTL	V_A = ±10V		11	V
Leakage Current "OFF" ($I_{D(OFF)}$)	5VTTL	V_{IN} = 4.5V, V_A = ±10V, T_A = 25°C	.02	.2	nA
		V_{IN} = 4.5V, V_A = ±10V		10	nA
Leakage Current "OFF" ($I_{D(OFF)}$)	15VTTL	V_{IN} = +11V, V_A = ±10V, T_A = 25°C	.02	.2	nA
		V_{IN} = +11V, V_A = ±10V		10	nA
Leakage Current "ON" ($I_{D(ON)}$)	5VTTL	V_{IN} = 0V, I_S = 1mA, T_A = 25°C	.3	1	nA
		V_{IN} = 0V, I_S = 1 mA		.2	μA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	V_{IN} = 0V, I_S = 1 mA, T_A = 25°C	.1	.5	nA
		V_{IN} = 0V, I_S = 1 mA		.1	μA
Leakage Current "ON" ($I_{D(ON)}$)	5VTTL	V_{IN} = 0V, I_S = 2 mA, T_A = 25°C		1	μA
		V_{IN} = 0V, I_S = 2 mA		10	μA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	V_{IN} = 0V, I_S = 2 mA, T_A = 25°C		2	nA
		V_{IN} = 0V, I_S = 2 mA		1	μA
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	5VTTL	V_{IN} = 0.5V, I_D = 2 mA, T_A = 25°C	90	150	Ω
		V_{IN} = 0.5V, I_D = 2 mA		240	Ω
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	15VTTL	V_{IN} = 1.5V, I_D = 2 mA, T_A = 25°C	60	100	Ω
		V_{IN} = 1.5V, I_D = 2 mA		160	Ω
$r_{DS(ON)}$ Match (Effective $r_{DS(ON)}$)($r_{DS(ON)}$ EFF.)	15VTTL MUX	V_{IN} = 1.5V, I_D = 2 mA		50	Ω
	5VTTL MUX	V_{IN} = 0.5V, I_D = 2 mA			
Turn-On Time ($t_{(ON)}$)	All	See AC Test Circuits, T_A = 25°C	150	500	ns
Turn-Off Time ($t_{(OFF)}$)	All	See AC Test Circuits, T_A = 25°C	300	500	ns
Cross Talk (CT)	All	See AC Test Circuits, T_A = 25°C	120		dB

Note 1: Unless otherwise noted, these specifications apply for −25°C to +85°C for AH5009C through AH5012C.

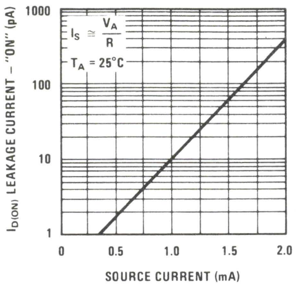
Note 2: "OFF" and "ON" notation refers to the conduction state of the FET switch.

typical performance characteristics

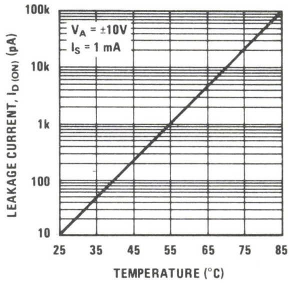
Maximum Power Dissipation



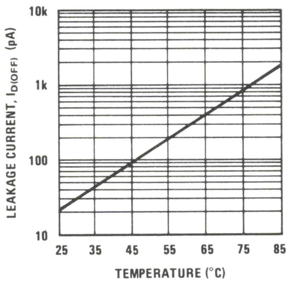
Leakage Current, $I_{D(ON)}$ vs I_S



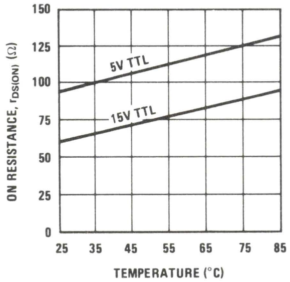
Leakage Current, $I_{D(ON)}$ vs Temperature



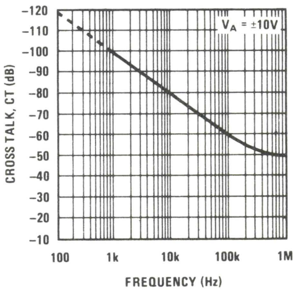
Leakage Current, $I_{D(OFF)}$ vs Temperature



On Resistance, $r_{DS(ON)}$ vs Temperature

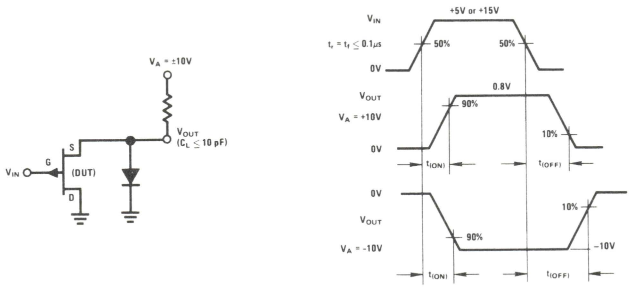


Cross Talk, CT vs Frequency

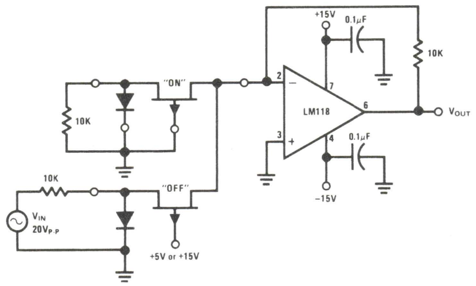


test circuits

AC Switching Test Circuits



Cross Talk Test Circuit



7

applications information

Theory of Operation

The AH5009 series of analog switches are primarily intended for operation in current mode switch applications; i.e., the drains of the FET switch are held at or near ground by operating into the summing junction of an operational amplifier. Limiting the drain voltage to under a few hundred mV eliminates the need for a special gate driver. Thus, the switch may be controlled with conventional TTL elements (5V) or with the open collector (15V) structures.

Two basic switch configurations are available: multiple independent switches (N by SPST) and multiple pole switches used for multiplexing (NPST-MUX). The MUX versions such as the AH5009 offer common drains and include a series FET operated at V_{GS} = 0V. The additional FET is placed in feedback path in order to compensate for the "ON" resistance of the switch FET as shown in Figure 1.

The closed-loop gain of Figure 1 is:

$$A_{VCL} = \frac{R_2 + r_{DS(ON)Q2}}{R_1 + r_{DS(ON)Q1}}$$

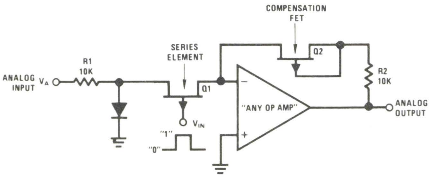


FIGURE 1. Use of Compensation FET

For $R_1 = R_2$, gain accuracy is determined by the $r_{DS(ON)}$ match between Q_1 and Q_2. Standard match between Q_1 and Q_2 is 50Ω resulting in a gain accuracy of 0.5% (for $R_1 = R_2 = 10k$). Tighter $r_{DS(ON)}$ match versions are available.

Noise Immunity

The switches with the source diodes grounded exhibit improved noise immunity for positive analog signals in the "OFF" state. With V_{IN} = 15V and the V_A = +10V, the source of Q_1 is clamped to about 0.6V by the diode (V_{GS} = 14.4V). The "ON" impedance of the diode is about 26Ω ensuring that AC signals imposed on the +10V will not gate the FET "ON."

Selection of Gain Setting Resistors

Since the AH5009 series of analog switches are operated current mode, it is generally advisable to make the signal current as large as possible. However, current through the FET switch tends to forward bias the gate to channel (source) diode resulting in leakage across the diode. This leakage, $I_{D(ON)}$, increases exponentially with increasing I_S. As shown in Figure 2, $I_{D(ON)}$ represents a finite error in the current reaching the summing junction of the op amp.

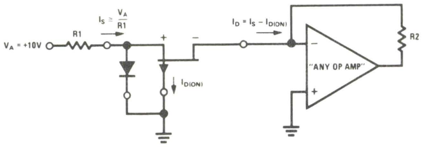


FIGURE 2. On Leakage Current, $I_{D(ON)}$

Secondly, the $r_{DS(ON)}$ of the FET begins to "round" as I_S approaches I_{DSS}. A practical rule of thumb is to maintain I_S at less than 1/10 of I_{DSS}.

Combining the criteria from the above discussion yields:

$$R_{1(MIN)} \geq \frac{V_{A(MAX)}\ A_D}{I_{D(ON)}} \quad (2a)$$

or:

$$\geq \frac{V_{A(MAX)}}{I_{DSS}/10} \quad (2b)$$

which ever is worse.

Where: $V_{A(MAX)}$ = Peak amplitude of the analog input signal

A_D = Desired accuracy

$I_{D(ON)}$ = Leakage at a given I_S

I_{DSS} = Saturation current of the FET switch

≅ 20 mA

In a typical application, V_A might = ±10V, A_D = 0.1%, 0°C ≤ T_A ≤ 85°C. The criterion of equation (2b) predicts:

$$R_{1(MIN)} \geq \frac{10V}{\frac{20MA}{10}} = 5k\Omega$$

For R_1 = 5k, I_S ≅ 10V/5k or 2 mA. The electrical characteristics guarantee an $I_{D(ON)} \leq 1\mu A$ at 85°C for the AH5010C. Per the criterion of equation (2a):

$$R_{1(MIN)} \geq \frac{(10V)(10^{-3})}{1 \times 10^{-6}} \geq 10k\Omega$$

Since equation (2a) predicts a higher value, the 10k resistor should be used.

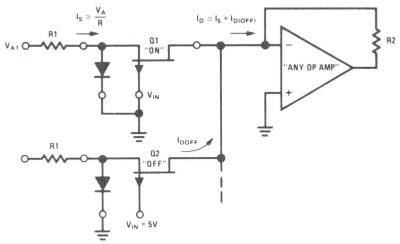


FIGURE 3.

The "OFF" condition of the FET also effects gain accuracy. As shown in Figure 3, the leakage across Q_2, $I_{D(OFF)}$ represents a finite error in the current arriving at the summing junction of the op amp.

applications information (con't)

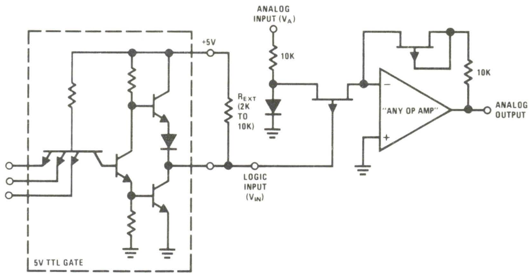


FIGURE 4. Interfacing with +5V Logic

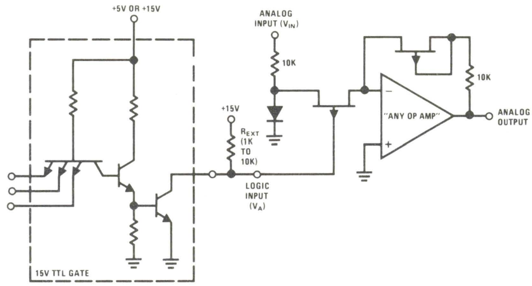


FIGURE 5. Interfacing with +15V Open Collector Logic

Accordingly:

$$R_{1(MAX)} \leq \frac{V_{A(MIN)}\ A_D}{(N)\ I_{D(OFF)}}$$

Where: $V_{A(MIN)}$ = Minimum value for the analog input signal

A_D = Desired accuracy

N = Number of channels

$I_{D(OFF)}$ = OFF leakage of a given FET switch

As an example, if N = 10, A_D = 0.1%, and $I_{D(OFF)} \leq$ 10 nA at 85°C for the AH5009C, $R_{1(MAX)}$ is:

$$R_{1(MAX)} \leq \frac{(1V)(10^{-3})}{(10)(10 \times 10^{-9})} = 10k$$

Selection of R_2, of course, depends on the gain desired and for unity gain $R_1 = R_2$.

Lastly, the foregoing discussion has ignored resistor tolerances, input bias current and offset voltage of the op amp — all of which should be considered in setting the overall gain accuracy of the circuit.

TTL Compatibility

Two input logic drive versions of AH5009 series are available: the even numbered part types are specified to be driven from standard 5V-TTL logic and the odd numbered types from 15V open collector TTL.

Standard TTL gates pull-up to about 3.5V (no load). In order to ensure turn-off of the even numbered switches such as AH5010, a pull-up resistor, R_{EXT}, of at least 10 kΩ should be placed between the 5V V_{CC} and the gate output as shown in Figure 4.

Likewise, the open-collector, high voltage TTL outputs should use a pull-up resistor as shown in Figure 5. In both cases, $t_{(OFF)}$ is improved for lower values of R_{EXT} and the expense of power dissipation in the low state.

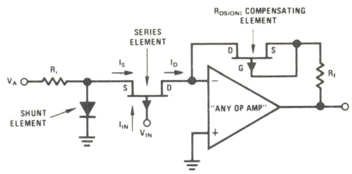


FIGURE 6. Definition of Terms

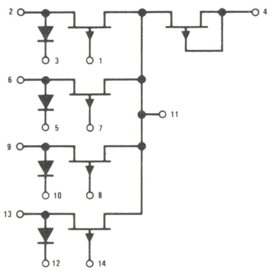
Definition of Terms

The terms referred to in the electrical characteristics tables are as defined in Figure 6.

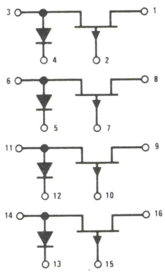
device schematics and pin connections

FOUR CHANNEL

AH5009CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5010CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
14 PIN DIP

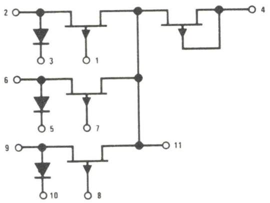


AH5011CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5012CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
16 PIN DIP

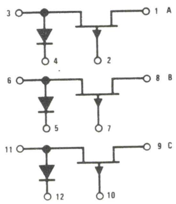


THREE CHANNEL

AH5013CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5014CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
14 PIN DIP

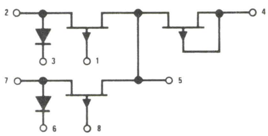


AH5015CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5016CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
16 PIN DIP

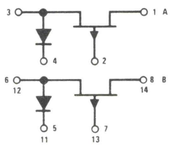


TWO CHANNEL

AH5017CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5018CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
8 PIN DIP

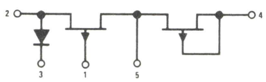


AH5019CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5020CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
8 PIN DIP

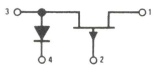


SINGLE CHANNEL

AH5021CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5022CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
8 PIN DIP



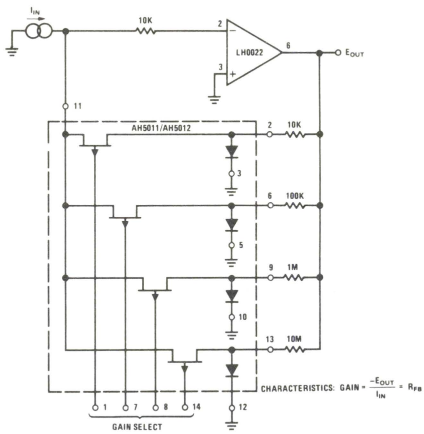
AH5023CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
AH5024CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
8 PIN DIP



Package Types — 8, 14, 16 pin epoxy "B"

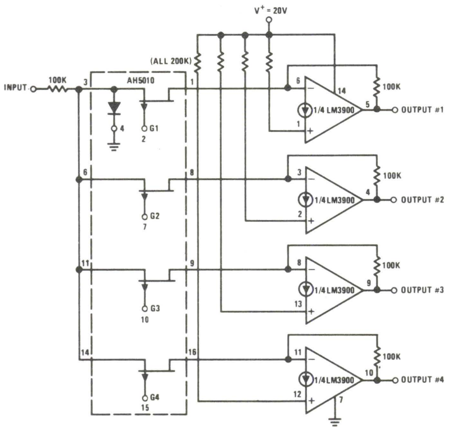
typical applications

Gain Programmable Amplifier

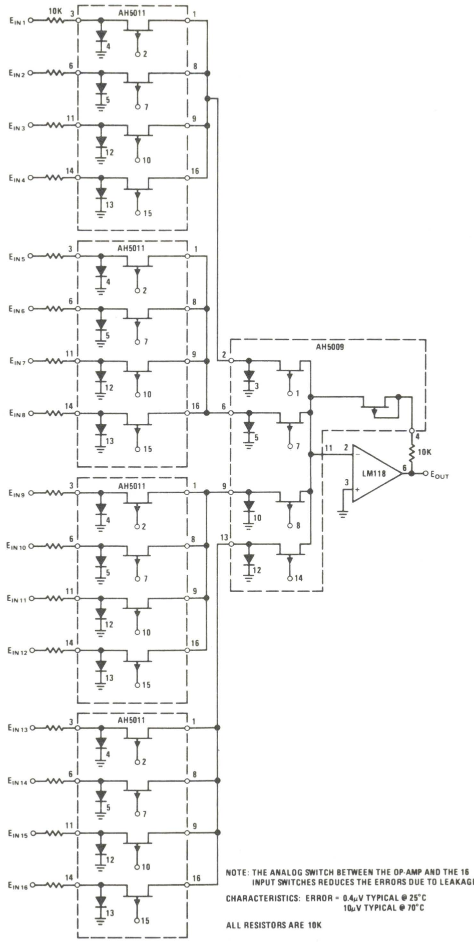


CHARACTERISTICS: GAIN = $\frac{-E_{OUT}}{I_{IN}} = R_{FB}$

Low Cost Demultiplexer



16-Channel Multiplexer

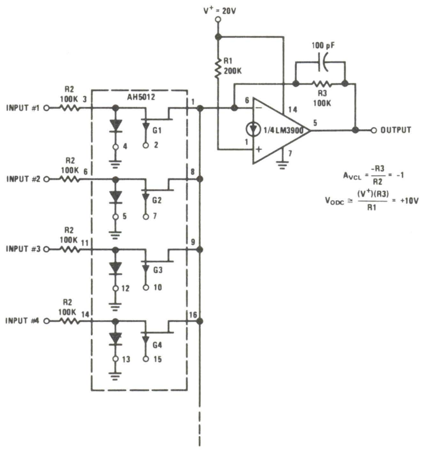


NOTE: THE ANALOG SWITCH BETWEEN THE OP-AMP AND THE 16 INPUT SWITCHES REDUCES THE ERRORS DUE TO LEAKAGE.

CHARACTERISTICS: ERROR = 0.4μV TYPICAL @ 25°C
10μV TYPICAL @ 70°C

ALL RESISTORS ARE 10K

Low Cost Multiplexer/Mixer



$A_{VCL} = \frac{-R3}{R2} = -1$

$V_{ODC} \geq \frac{(V^+)(R3)}{R1} = +10V$

Analog Switches

AM1000,AM1001,AM1002 silicon N-channel high speed analog switch

general description

The AM1000 series are junction FET integrated circuit analog switches. These devices commutate faster and with less voltage spiking than any other analog switch presently available. By comparison, discrete JFET switches require elaborate drive circuits to obtain reasonable performance for high toggle rates. Encapsulated in a four pin TO-72 package, these units require a minimum of circuit board area. Switching transients are greatly reduced by a monolithic integrated circuit process. The resulting analog switch device provides the following features:

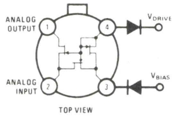
- Low ON Resistance 30Ω
- High Analog Signal Frequency 100 MHz
- High Toggle Rate 4 MHz
- Low Leakage Current 250 pA
- Large Analog Signal Swing ±15V
- Break Before Make Action

The AM1000 series of analog switches are particularly suitable for the following applications:

- High Speed Commutators
- Multiplexers
- Sample and Hold Circuits
- Reset Switching
- Video Switching

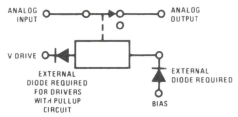
schematic and connection diagram

TO-72 Package



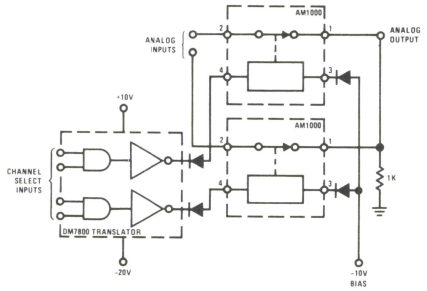
Order Number AM1000H or AM1001H or AM1002H See Package 9A

equivalent circuit

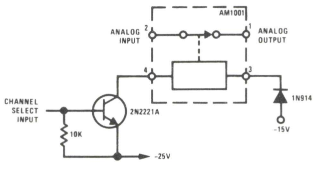


typical applications

±10 Volt Swing Analog Switch 0.5% Accuracy



±15 Volt Swing Analog Switch



absolute maximum ratings

	AM1001	AM1000 AM1002
V_{IN} (Note 1)	+50V	+40V
V_{OUT} (Note 1)	+50V	+40V
V_{DRIVE} (Note 1)	–50V	–40V
V_{BIAS} (Note 1)	+50V	+40V

Power Dissipation @ $T_A = 25°C$	300 mW
Linear Derating Factor	1.7 mW/°C
Power Dissipation @ $T_C = 125°C$	150 mW
Linear Derating Factor	6 mW/°C
Maximum Junction Operating Temperature	–55°C to +150°C
Storage Temperature	+200°C
Lead Temperature (Soldering, 10 sec)	+300°C

electrical characteristics

ON CHARACTERISTICS (Note 2)

PARAMETER	CONDITION		MIN	TYP	MAX	UNITS
R_{ON}	$V_{DRIVE} = +15V$, $V_{BIAS} = -15V$ $I_{IN} = 1$ mA, $V_{OUT} = 0V$	AM1001	20	40	50	Ω
R_{ON}	$V_{DRIVE} = +10V$, $V_{BIAS} = -10V$ $I_{IN} = 1$ mA, $V_{OUT} = 0V$	AM1000	20	25	30	Ω
		AM1002	20	50	100	Ω

OFF CHARACTERISTICS

PARAMETER	CONDITION	AM1000 AM1001			AM1002			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ $V_{IN} = -10V$, $V_{OUT} = +10V$							
	$T_A = +25°C$		.05	.25		0.5	1	nA
	$T_A = +125°C$		.025	.25		0.2	1	µA
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ $V_{IN} = +10V$, $V_{OUT} = -10V$							
	$T_A = +25°C$		.05	.25		0.5	1	nA
	$T_A = +125°C$		.05	.25		0.2	1	µA

DRIVE CHARACTERISTICS (Note 3)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
I_{DRIVE} (Switch OFF)	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ AM1000, 1001, 1002 $V_{IN} = \pm 10V$, $V_{OUT} = \pm 10V$		5	10	mA

SWITCHING CHARACTERISTICS

PARAMETER	CONDITION	AM1000 MAX	AM1001 MAX	AM1002 MAX	UNITS
t_{ON}	See Switching Time Test Circuit	100	150	200	ns
t_{OFF}		100	100	100	ns

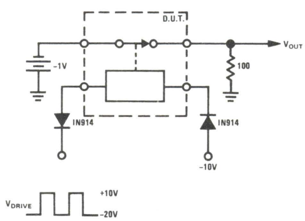
Note 1: The maximum voltage ratings may be applied between any pin or pins simultaneously. Power dissipation may be exceeded in some modes if the voltage pulse exceeds 10 ms. Normal operation will not cause excessive power dissipation even in a "D.C." switching application.

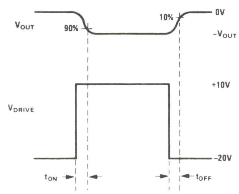
Note 2: All parameters are measured with external silicon diodes. See electrical connection diagram for proper diode placement.

Note 3: I_{BIAS} (Switch OFF) is equal to I_{DRIVE} (Switch OFF). $I_{(BIAS)}$ (Switch ON), is equal to external diode leakage.

Note 4: Rise and fall times of V_{DRIVE} shall be 15 ns maximum for switching time testing.

switching time test circuit and waveforms





Analog Switches

AM2009/AM2009C/MM4504/MM5504
six channel MOS multiplex switches

general description

The AM2009/AM2009C/MM4504/MM5504 are six channel multiplex switches constructed on a single silicon chip using low threshold P-channel MOS process. The gate of each MOS device is protected by a diode circuit.

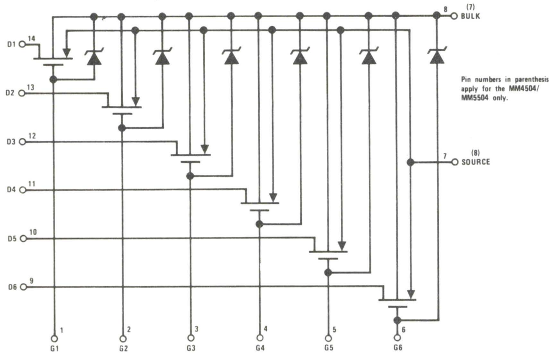
The AM2009/AM2009C/MM4504/MM5504 are designed for applications such as time division multiplexing of analog or digital signals. Switching speeds are primarily determined by conditions external to the device such as signal source impedance, capacitive loading and the total number of channels used in parallel.

The AM2009/MM4504 are specified for operation over the -55°C to +125°C military temperature range. The AM2009C/MM5504 are specified for operation over the -25°C to +85°C temperature range.

features

- Typical low "on" resistance 150Ω
- Typical low "off" leakage 100 pA
- Typical large analog voltage range ±10V
- Zero inherent offset voltage
- Normally off with zero gate voltage

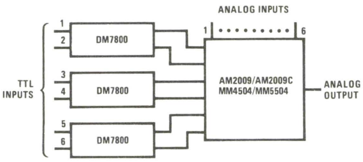
schematic diagram



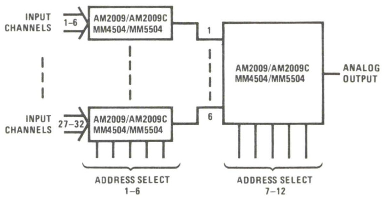
Order Number
AM2009F or AM2009CF
MM4504F or MM5504F
See Package 4

Order Number
AM2009D or AM2009CD
MM4504D or MM5504D
See Package 1

typical applications



TTL Compatible 6 Channel MUX



32 Channel MUX

absolute maximum ratings (V_{BULK} = 0V)

Voltage on Any Source or Drain	−30V
Voltage on Any Gate	−35V
Positive Voltage on Any Pin	+0.3V
Source or Drain Current	50 mA
Gate Current (forward direction of zener clamp)	0.1 mA
Total Power Dissipation (at T_A = 25°C)	900 mW
Power Dissipation — each gate circuit	150 mW
Operating Temperature Range AM2009	−55°C to +125°C
AM2009C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
Threshold Voltage	$V_{GS} = V_{DS}$, $I_{DS} = -1\ \mu A$	−1.0		−3.0	V
DC ON Resistance	$V_{GS} = -20V$, $I_{DS} = -100\ \mu A$, $T_A = 25°C$		150	250	Ω
DC ON Resistance	$V_{GS} = -10V$, $V_{SB} = -20V$, $I_{DS} = -100\ \mu A$, $T_A = 25°C$		500	1250	Ω
DC ON Resistance	$V_{GS} = -20V$, $I_{DS} = -100\ \mu A$			325	Ω
DC ON Resistance	$V_{GS} = -10V$, $V_{SB} = -20V$, $I_{DS} = -100\ \mu A$			1500	Ω
Gate Leakage	$V_{GS} = -20V$, Note 2			1.0	μA
	$V_{GS} = -20V$, Note 2, $T_A = 25°C$		100		pA
Input Leakage	$V_{DS} = -20V$, Note 2			1.0	μA
	$V_{DS} = -20V$, Note 2, $T_A = 25°C$		100		pA
Output Leakage	$V_{SD} = -20V$, Note 2			3.0	μA
	$V_{SD} = -20V$, Note 2, $T_A = 25°C$		500		pA
Gate-Bulk Breakdown Voltage	$I_{GB} = -10\ \mu A$, Note 2	−35			V
Source-Drain Breakdown Voltage	$I_{SD} = -10\ \mu A$, $V_{GD} = 0$, Note 2	−30			V
Drain-Source Breakdown Voltage	$I_{DS} = -10\ \mu A$, $V_{GS} = 0$, Note 2	−30			V
Transconductance			4000		mhos
Gate Capacitance	Note 3, f = 1 MHz		4.7	8	pF
Input Capacitance	Note 3, f = 1 MHz		4.6	8	pF
Output Capacitance	Note 3, f = 1 MHz		16	20	pF

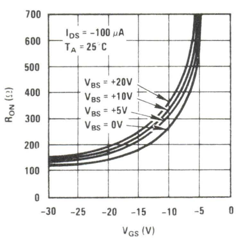
Note 1: Ratings apply over the specified temperature range and V_{BULK} = 0, unless otherwise specified.

Note 2: All other pins grounded.

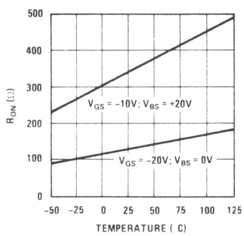
Note 3: Capacitance measured on dual-in-line package between pin under measurement to all other pins. Capacitances are guaranteed by design.

typical performance characteristics

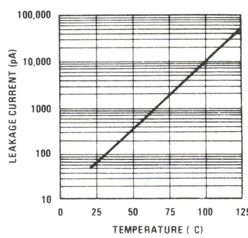
"ON" Resistance vs Gate-to-Source Voltage



"ON" Resistance vs T Temperature



Input Leakage Current vs Temperature



Analog Switches

AM3705/AM3705C 8-channel MOS analog multiplexer

general description

The AM3705/AM3705C is an eight-channel MOS analog multiplex switch. TTL compatible logic inputs that require no level shifting or input pull-up resistors and operation over a wide range of supply voltages is obtained by constructing the device with low threshold P-channel enhancement MOS technology. To simplify external logic requirements, a one-of-eight decoder and an output enable are included in the device.

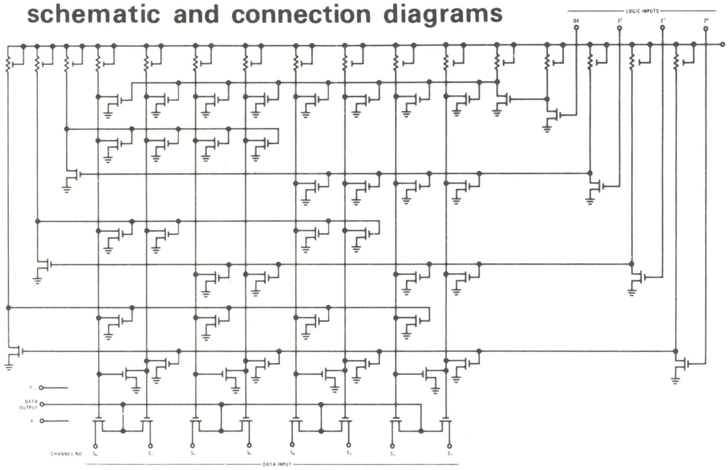
Important design features include:

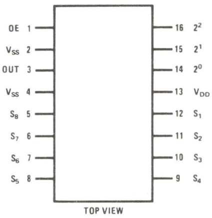
- TTL/DTL compatible input logic levels
- Operation from standard +5V and −15V supplies
- Wide analog voltage range — ±5V
- One-of-eight decoder on chip
- Output enable control
- Low ON resistance — 150Ω
- Input gate protection
- Low leakage currents — 0.5 nA

The AM3705/AM3705C is designed as a low cost analog multiplex switch to fulfill a wide variety of data acquisition and data distribution applications including cross-point switching, MUX front ends for A/D converters, process controllers, automatic test gear, programmable power supplies and other military or industrial instrumentation applications.

The AM3705 is specified for operation over the −55°C to +125°C military temperature range. The AM3705C is specified for operation over the −25°C to +85°C temperature range.

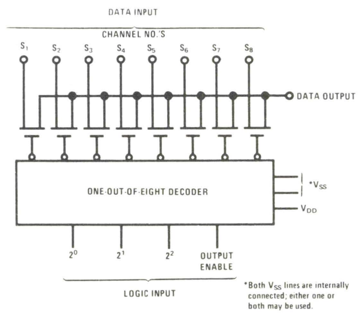
schematic and connection diagrams





Order Number
AM3705D or AM3705CD
See Package 2
AM3705F or AM3705CF
See Package 5

block diagram (MIL-STD-806B)



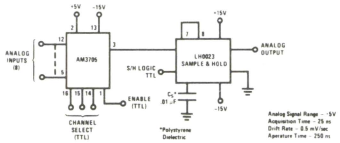
*Both V_{SS} lines are internally connected; either one or both may be used.

truth table

LOGIC INPUTS				CHANNEL
2^0	2^1	2^2	OE	ON
L	L	L	H	S_1
H	L	L	H	S_2
L	H	L	H	S_3
H	H	L	H	S_4
L	L	H	H	S_5
H	L	H	H	S_6
L	H	H	H	S_7
H	H	H	H	S_8
X	X	X	L	OFF

typical application

Buffered 8-Channel Multiplex, Sample and Hold



absolute maximum ratings

Positive Voltage on Any Pin (Note 1)	+0.3V
Negative Voltage on Any Pin (Note 1)	−35V
Source to Drain Current	±30 mA
Logic Input Current	±0.1 mA
Power Dissipation (Note 2)	500 mW
Operating Temperature Range AM3705	−55°C to +125°C
AM3705C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	SYMBOL	CONDITIONS	LIMITS MIN	TYP	MAX	UNITS
ON Resistance	R_{ON}	$V_{IN} = V_{SS}$; $I_{OUT} = 100\,\mu A$		80	250	Ω
ON Resistance	R_{ON}	$V_{IN} = -5V$; $I_{OUT} = -100\,\mu A$		160	400	Ω
ON Resistance	R_{ON}	$V_{IN} = -5V$; $I_{OUT} = -100\,\mu A$				
AM3705		$T_A = +125°C$			400	Ω
AM3705C		$T_A = +70°C$			400	Ω
ON Resistance	R_{ON}	$V_{IN} = +5V$; $V_{DD} = -15V$; $I_{OUT} = 100\,\mu A$		100		Ω
ON Resistance	R_{ON}	$V_{IN} = 0V$, $V_{DD} = -15V$, $I_{OUT} = -100\,\mu A$		150		Ω
ON Resistance	R_{ON}	$V_{IN} = -5V$; $V_{DD} = -15V$; $I_{OUT} = -100\,\mu A$		250		Ω
OFF Resistance	R_{OFF}			10^{10}		Ω
Output Leakage Current	I_{LO}	$V_{SS} - V_{OUT} = 15V$		0.5	10	nA
AM3705	I_{LO}	$V_{SS} - V_{OUT} = 15V$; $T_A = 125°C$		150	500	nA
AM3705C	I_{LO}	$V_{SS} - V_{OUT} = 15V$; $T_A = 70°C$		35	500	nA
Data Input Leakage Current	I_{LDI}	$V_{SS} - V_{IN} = 15V$		0.1	3.0	nA
AM3705	I_{LDI}	$V_{SS} - V_{IN} = 15V$; $T_A = 125°C$		25	500	nA
AM3705C	I_{LDI}	$V_{SS} - V_{IN} = 15V$; $T_A = 70°C$		0.5	500	nA
Logic Input Leakage Current	I_{LI}	$V_{SS} - V_{Logic\,In} = 15V$		.001	1	μA
AM3705	I_{LI}	$V_{SS} - V_{Logic\,In} = 15V$; $T_A = 125°C$		.05	10	μA
AM3705C	I_{LI}	$V_{SS} - V_{Logic\,In} = 15V$; $T_A = 70°C$		.05	10	μA
Logic Input LOW Level	V_{IL}	$V_{SS} = +5.0V$		0.5	1.0	V
Logic Input LOW Level	V_{IL}		V_{DD}		$V_{SS} - 4.0$	V
Logic Input HIGH Level	V_{IH}	$V_{SS} = +5.0V$	3.0	3.5		V
Logic Input HIGH Level	V_{IH}		$V_{SS} - 2.0$		$V_{SS} + 0.3$	V
Channel Switching Time-Positive	t^+	Switching Time		300		ns
Channel Switching Time-Negative	t^-	Test Circuit		600		ns
Channel Separation		f = 1 kHz		62		dB
Output Capacitance	C_{db}	$V_{SS} - V_{OUT} = 0$; f = 1 MHz		35		pF
Data Input Capacitance	C_{sb}	$V_{SS} - V_{DIP} = 0$; f = 1 MHz		6.0		pF
Logic Input Capacitance	C_{cg}	$V_{SS} - V_{Logic\,In} = 0$; f = 1 MHz		6.0		pF
Power Dissipation	P_D	$V_{DD} = -31V$, $V_{SS} = 0V$		125	175	mW

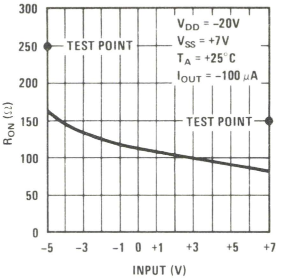
Note 1: All voltages referenced to V_{SS}.

Note 2: Rating applies for ambient temperatures to +25°C, derate linearly at 3 mW/°C for ambient temperatures above +25°C.

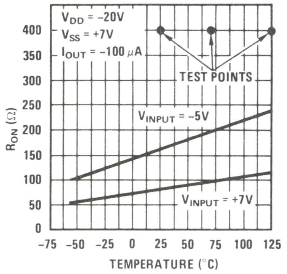
Note 3: Specifications apply for $T_A = 25°C$, $-24V \le V_{DD} \le -20V$, and $+5.0V \le V_{SS} \le +7.0V$; unless otherwise specified (all voltages are referenced to ground).

typical performance characteristics

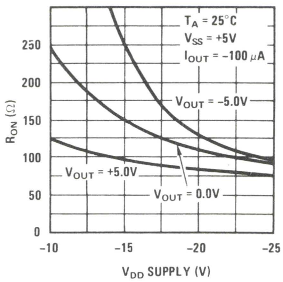
ON Resistance vs Analog Input Voltage



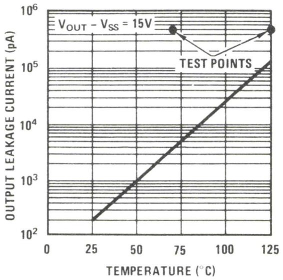
ON Resistance vs Ambient Temperature



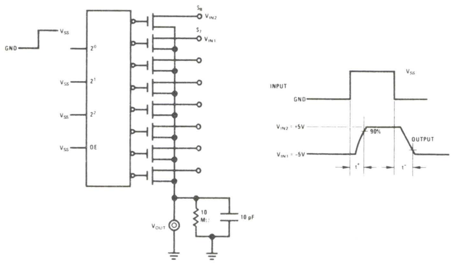
ON Resistance vs V_{DD} Supply Voltage



Output Leakage Current vs Ambient Temperature

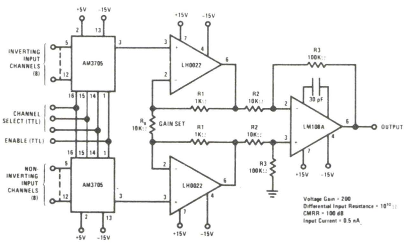


switching time test circuit

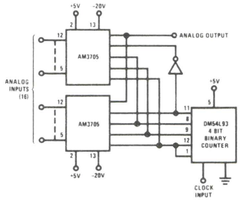


typical applications (con't.)

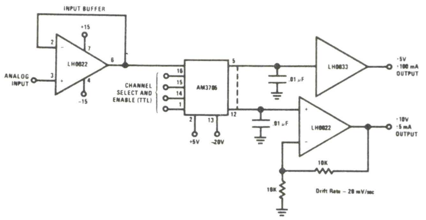
Differential Input MUX



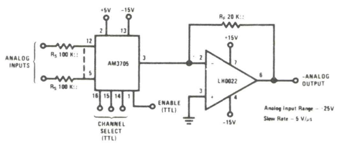
16-Channel Commutator



8-Channel Demultiplexer with Sample and Hold



Wide Input Range Analog Switch



Analog Switches

MM450/MM550, MM451/MM551
MM452/MM552, MM455/MM555 MOS analog switches

general description

The MM450, and MM550 series each contain four p channel MOS enhancement mode transistors built on a single monolithic chip. The four transistors are arranged as follows:

MM450, MM550	Dual Differential Switch
MM451, MM551	Four Channel Switch
MM452, MM552	Four MOS Transistor Package
MM455, MM555	Three MOS Transistor Package

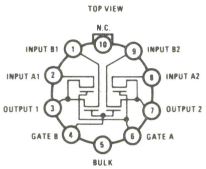
These devices are useful in many airborne and ground support systems requiring multiplexing, analog transmission, and numerous signal routing applications. The use of low threshold transistors (V_{TH} = 2 volts) permits operations with large analog input swings (± 10 volts) at low gate voltages (−20 volts). Significant features, then, include:

- Large Analog Input Swing ±10 Volts
- Low Supply Voltage V_{BULK} = +10 Volts, V_{GG} = −20 Volts
- Low ON Resistance V_{IN} = −10V 150Ω, V_{IN} = +10V 75Ω
- Low Leakage Current 200 pA @ 25°C
- Input Gate Protection
- Zero Offset Voltage

Each gate input is protected from static charge build-up by the incorporation of zener diode protective devices connected between the gate input and device bulk.

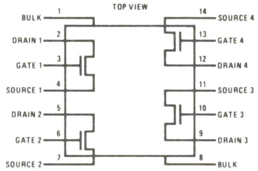
The MM450, MM451, MM452 and MM455 are specified for operation over the −55°C to +125°C military temperature range. The MM550, MM551, MM552 and MM555 are specified for operation over the −25°C to +70°C temperature range.

schematic and connection diagrams



NOTE: Pin 5 connected to case and device bulk.
MM450, MM550

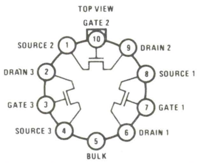
Order Number MM450H or MM550H
See Package 12



NOTE 1: Pins 1 and 8 connected to case and device bulk. Drain and Source may be interchanged. MM452F, MM552F.
NOTE 2: MM452D and MM552D (dual-in-line packages) have same pin connections as MM452F and MM552F shown above.

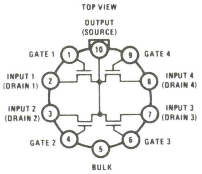
Order Number MM452F or MM552F
See Package 4

Order Number MM452D or MM552D
See Package 1



NOTE: Pin 5 connected to case and device bulk. Drain and Source may be interchanged.
MM455, MM555

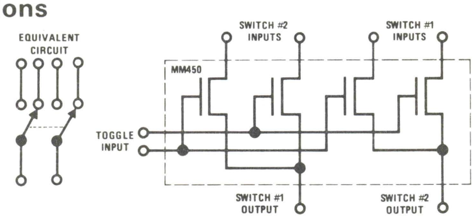
Order Number MM455H or MM555H
See Package 12



NOTE: Pin 5 connected to case and device bulk.
MM451, MM551

Order Number MM451H or MM551H
See Package 12

typical applications



DPDT Analog Switch

absolute maximum ratings

	MM450, MM451, MM452, MM455	MM550, MM551, MM552, MM555
Gate Voltage (V_{GG})	+10V to −30V	+10V to −30V
Bulk Voltage (V_{BULK})	+10V	+10V
Analog Input (V_{IN})	+10V to −20V	+10V to −20V
Power Dissipation	200 mW	200 mW
Operating Temperature	−55°C to +125°C	−25°C to 70°C
Storage Temperature	−65°C to +150°C	−65°C to +150°C

electrical characteristics

STATIC CHARACTERISTICS (Note 1)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Analog Input Voltage				±10	V
Threshold Voltage ($V_{GS(T)}$)	$V_{DG} = 0$, $I_D = 1\ \mu A$	1.0	2.2	3.0	V
ON Resistance	$V_{IN} = -10V$		150	600	Ω
ON Resistance	$V_{IN} = V_{SS}$		75	200	Ω
OFF Resistance			10^{10}		Ω
Gate Leakage Current (I_{GSB})	$V_{GS} = -25V$, $V_{BS} = 0$, $T_A = 25°C$		20		pA
Input (Drain) Leakage Current					
MM450, MM451, MM452, MM455	$T_A = 25°C$		.025	100	nA
	$T_A = 85°C$		.002	1.0	μA
	$T_A = 125°C$		.025	1.0	μA
Input (Drain) Leakage Current					
MM550, MM551, MM552, MM555	$T_A = 25°C$		0.1	100	nA
	$T_A = 70°C$		.030	1.0	μA
Output (Source) Leakage Current					
MM450, MM451, MM452, MM455	$T_A = 25°C$		.040	100	nA
Output (Source) Leakage Current					
MM450	$T_A = 85°C$			1.0	μA
MM451	$T_A = 85°C$			1.0	μA
MM452, MM455	$T_A = 85°C$			1.0	μA
MM450, MM451, MM452, MM455	$T_A = 125°C$			1.0	μA
Output (Source) Leakage Current					
MM550	$T_A = 70°C$			1.0	μA
MM551	$T_A = 70°C$			1.0	μA
MM552, MM555	$T_A = 70°C$			1.0	μA

DYNAMIC CHARACTERISTICS

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Large Signal Transconductance	$V_{DS} = -10V$, $I_D = 10$ mA f = 1 kHz		4000		μmhos

CAPACITANCE CHARACTERISTICS (Note 2)

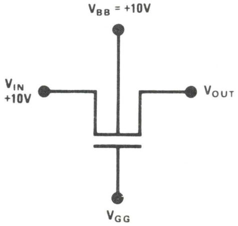
PARAMETER	DEVICE TYPE	MIN	TYP	MAX	UNITS
Analog Input (Drain) Capacitance (C_{DB})	ALL		8	10	pF
Output (Source) Capacitance (C_{SB})	MM450, MM550		11	14	pF
	MM451, MM551		20	24	pF
	MM452, MM552		7.5	11	pF
	MM455, MM555		7.5	11	pF
Gate Input Capacitance (C_{GB})	MM450, MM550		10	13	pF
	MM451, MM551		5.5	8	pF
	MM452, MM552		5.5	9	pF
	MM455, MM555		5.5	9	pF
Gate to Output Capacitance (C_{GS})	ALL		3.0	5	pF

Note 1: The resistance specifications apply for $-55°C \leq T_A \leq +85°C$, $V_{GG} = -20V$, $V_{BULK} = +10V$, and a test current of 1 mA. Leakage current is measured with all pins held at ground except the pin being measured which is biased at −25V.

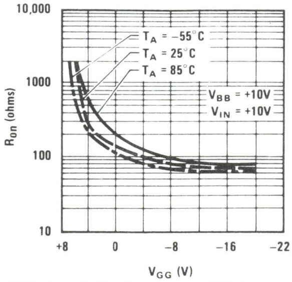
Note 2: All capacitance measurements are made at 0 volts bias at 1 MHz.

typical dynamic input characteristics (T_A = 25°C Unless Otherwise Noted)

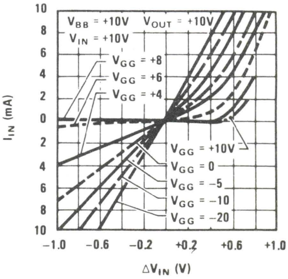
CONDITION 1:
ANALOG INPUT VOLTAGE
AT +10 VOLTS



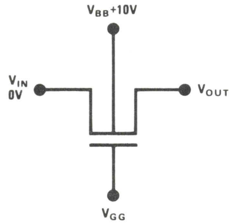
R_{on} vs V_{GG}



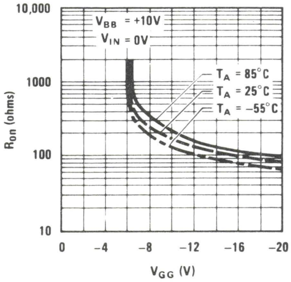
Dynamic R_{on}



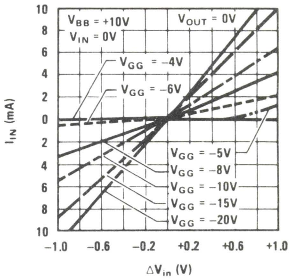
CONDITION 2:
ANALOG INPUT VOLTAGE
AT 0 VOLTS



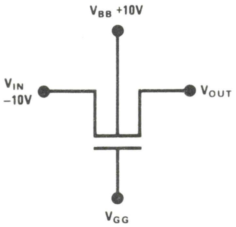
R_{on} vs V_{GG}



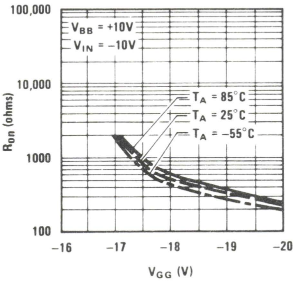
Dynamic R_{on}



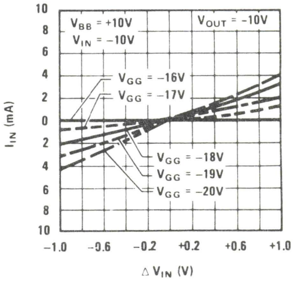
CONDITION 3:
ANALOG INPUT VOLTAGE
AT −10 VOLTS



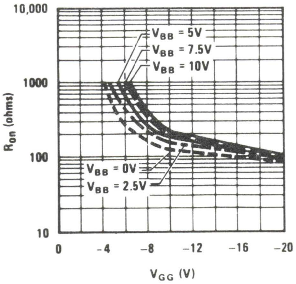
R_{on} vs V_{GG}



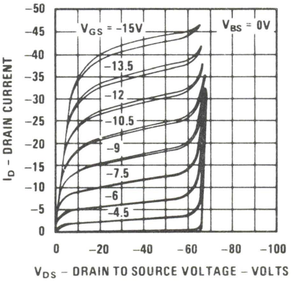
Dynamic R_{on}



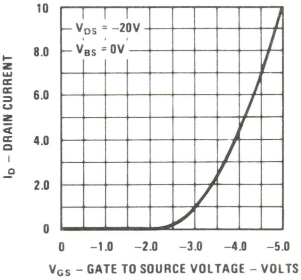
R_{on} vs V_{GG}



Typical Drain Characteristics

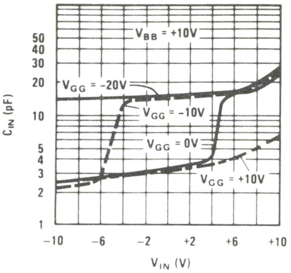


Drain Current vs
Gate To Source Voltage

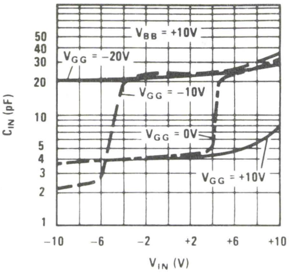


typical input capacitance characteristics

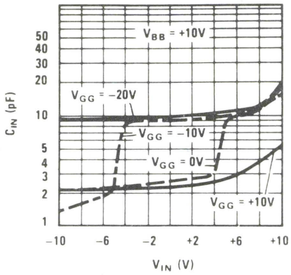
MM450, MM550
C_{IN} vs V_{IN}



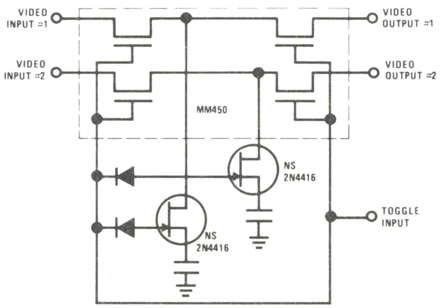
MM451, MM551
C_{IN} vs V_{IN}



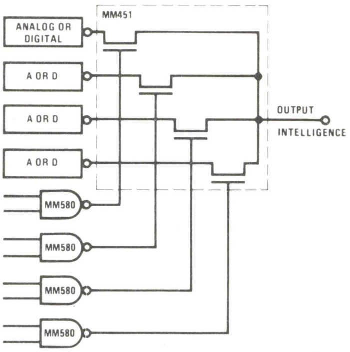
MM452, MM552, MM455, MM555
C_{IN} vs V_{IN}



typical applications (con't)



DPST High-Frequency Switch



4-Channel Multiplexer*

*Expansion in the number of data input lines is possible by using multiple level series switches allowing the same decode gates to be used for all lower rank decoding.

Analog Switches

MM454/MM554 four-channel commutator

general description

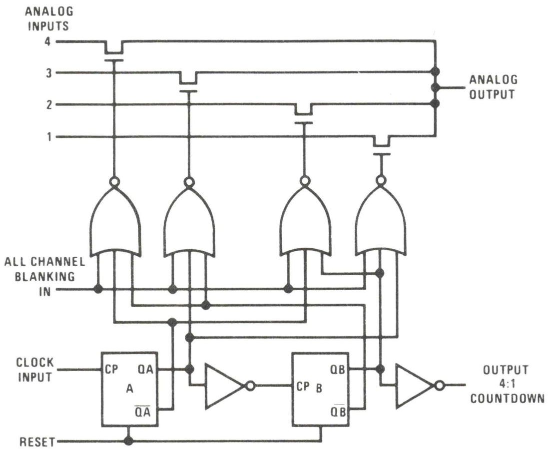
The MM454/MM554 is a four-channel analog commutator capable of switching four analog input channels sequentially onto an output line. The device is constructed on a single silicon chip using MOS P Channel enhancement transistors; it contains all the digital circuitry necessary to sequentially turn ON the four analog switch transistors permitting multiplexing of the analog input data. The device features:

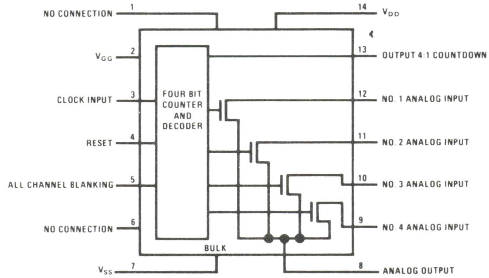
- High Analog Voltage Handling ±10V
- High Commutating Rate 500 kHz
- Low Leakage Current (T_A = 25°C) 200 pA; (T_A = 85°C) 50 nA
- All Channel Blanking input provided
- Reset capability provided
- Low ON Resistance 200Ω

In addition, the MM454/MM554 can easily be applied where submultiplexing is required since a 4:1 clock countdown signal is provided which can drive the clock input of subsequent MM454/MM554 units.

The MM454 is specified for operation over the −55°C to +125°C military temperature range. The MM554 is specified for operation over the −25°C to +70°C temperature range.

schematic and connection diagrams





NOTE: Pin 7 connected to case and to device bulk. Nominal Operating Voltages: V_{GG} = −24V; V_{DD} = 0V; V_{SS} = +12V, RESET BIAS = +12V (0V for RESET), ALL CHANNEL BLANKING BIAS = +12V (0V for BLANKING)

Order Number MM454F or MM554F
See Package 4

7

absolute maximum ratings (Note 1)

Gate Voltage (V_{GG})	+10V to −30V
Bulk Voltage (V_{SS})	+10V
Analog Input (V_{IN})	+10V to −20V
Power Dissipation	200 mW
Operating Temperature MM454	−55°C to +125°C
MM554	−25°C to +70°C
Storage Temperature	−65°C to +150°C

static characteristics (Note 2)

PARAMETER		CONDITION	MIN	TYP	MAX	UNITS
Analog Input Voltage					±10	V
ON Resistance		V_{IN} = −10V		170	600	Ω
ON Resistance		V_{IN} = V_{SS}		90	200	Ω
OFF Resistance				10^{10}		Ω
Analog Input Leakage Current	MM454	T_A = 25°C		.050	100	nA
	MM454	T_A = 85°C		.006	1.0	μA
	MM554	T_A = 25°C		.0001	100	nA
	MM554	T_A = 70°C		.030	1.0	μA
Analog Output Leakage Current	MM454	T_A = 25°C		0.100	100	nA
	MM454	T_A = 85°C		30	1.0	μA
	MM554	T_A = 25°C		.0001	100	nA
	MM554	T_A = 70°C		.030	1.0	μA
V_{SS} Supply Current Drain		V_{SS} = +12V		3.8	5.5	mA
V_{GG} Supply Current Drain		V_{GG} = −24V		2.4	3.5	mA

capacitance characteristics

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Analog Input Capacitance Channel OFF	I_{IN} = 0		4	6	pF
Analog Input Capacitance Channel ON	I_{IN} = 0		20	24	pF
Analog Output Capacitance	I_{IN} = 0		20	24	pF
Clock Input	V_{CL} = +12V		2.0		pF
Reset Input	V_{RESET} = +12V		2.0		pF
Blanking Input	V_{BLANK} = +12V		2.0		pF

clock characteristics (Note 3)

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Clock Input (HIGH)(4)		V_{SS} − 2		V_{SS}	V
Clock Input (LOW)		−5	0	+5	V
Clock Input Rise Time (POS GOING)			No requirement		
Clock Input Fall Time (NEG GOING)				20	μsec
Countdown Output (POS) V_{OH}		V_{SS} −2		V_{SS}	V
Countdown Output (NEG) V_{OL}			0		V
Maximum Commutation Rate		0.5	2.0		MHz
V_{SS}		+10.0	+12	+14	V

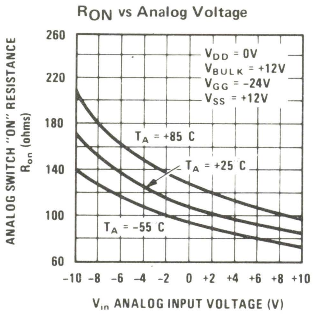
Note 1: Maximum ratings are limiting values above which the device may be damaged. All voltages referenced to V_{DD} = 0.

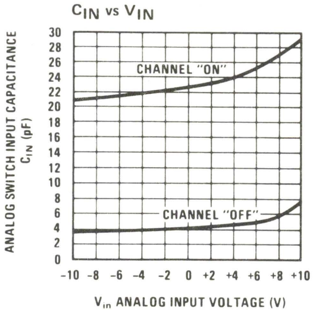
Note 2: These specifications apply over the indicated operating temperature range for V_{GG} = −24V, V_{DD} = 0V, V_{SS} = +12V, V_{RESET} = +12V, V_{BLANK} = +12V. ON resistance measured at 1 mA, OFF resistance and leakage measured with all analog inputs and output common. Capacitance measured at 1 MHz.

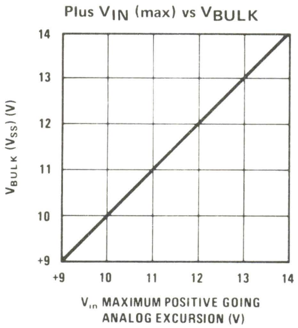
Note 3: Operating conditions in Note 2 apply. V_{SS} to V_{DD} (0V) voltage is applied to counting and gating circuits. V_{GG} is required only for analog switch biasing. All logic inputs are high resistance and are essentially capacitive.

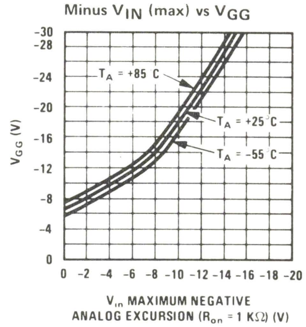
Note 4: Logic input voltage must not be more positive than V_{SS}.

typical performance characteristics

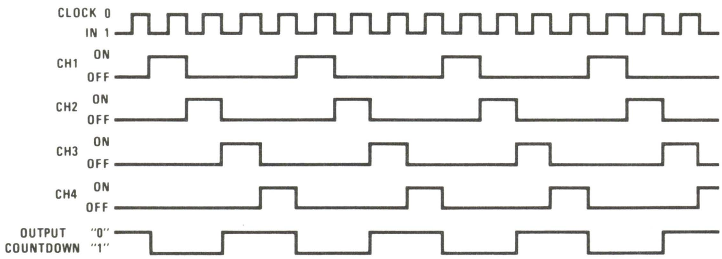








timing diagram



NOTE: "0" LEVEL = +12V
"1" LEVEL = 0V (GND)

Interface Circuits

LM1488 quad line driver

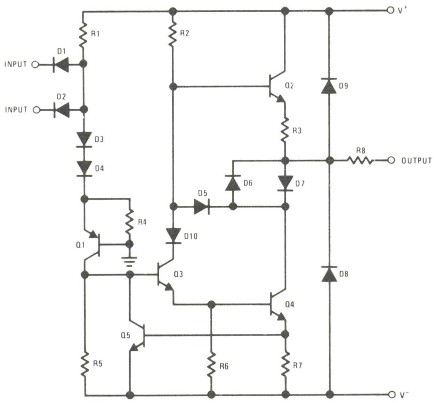
general description

The LM1488 is a quad line driver which converts standard DTL/TTL input logic levels through one stage of inversion to output levels which meet EIA Standard No. RS-232C and CCITT Recommendation V. 24.

features

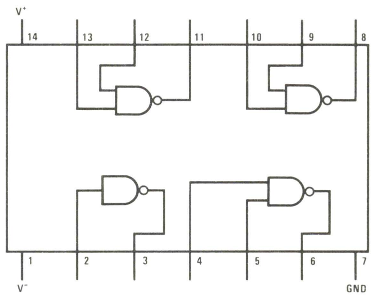
- Current limited output ±10 mA typ
- Power-off source impedance 300Ω min
- Simple slew rate control with external capacitor
- Flexible operating supply range
- Inputs are DTL/TTL compatible

schematic and connection diagrams



1/4 CIRCUIT

Dual-In-Line Package

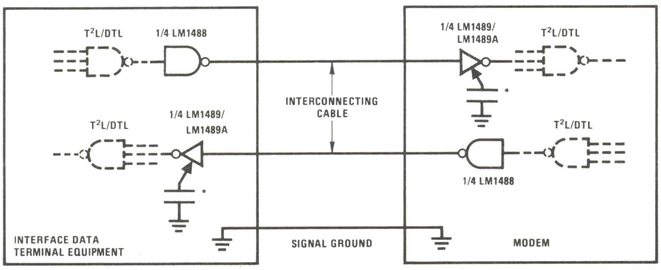


TOP VIEW

Order Number LM1488J
See Package 16

typical applications

RS232C Data Transmission



*OPTIONAL FOR NOISE FILTERING

absolute maximum ratings (Note 1)

Supply Voltage	
V^+	+15V
V^-	−15V
Input Voltage (V_{IN})	$-15V \leq V_{IN} \leq 7.0V$
Output Voltage	±15V
Power Derating (Note 2)	
(Package Limitation, J Package)	1000 mW
Derating above T_A = +25°C ($1/\theta_{JA}$)	6.7 mW/°C
Operating Temperature Range	0°C to +75°C
Storage Temperature Range	−65°C to +175°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Logic "0" Input Current	V_{IN} = 0V			−1.0	−1.3	mA
Logic "1" Input Current	V_{IN} = +5.0V			.005	10.0	μA
High Level Output Voltage	R_L = 3.0kΩ, V_{IN} = 0.8V	V^+ = 9.0V, V^- = −9.0V	6.0	7.0		V
		V^+ = 13.2V, V^- = −13.2V	9.0	10.5		V
Low Level Output Voltage	R_L = 3.0kΩ, V_{IN} = 1.9V	V^+ = 9.0V, V^- = −9.0V	−6.0	−6.8		V
		V^+ = 13.2V, V^- = −13.2V	−9.0	−10.5		V
High Level Output Short-Circuit Current	V_{OUT} = 0V, V_{IN} = 0.8V		−6.0	−10.0	−12.0	mA
Low Level Output Short-Circuit Current	V_{OUT} = 0V, V_{IN} = 1.9V		6.0	10.0	12.0	mA
Output Resistance	$V^+ = V^-$ = 0V, V_{OUT} = ±2V		300			Ω
Positive Supply Current (Output Open)	V_{IN} = 1.9V	V^+ = 9.0V, V^- = −9.0V		15.0	20.0	mA
		V^+ = 12V, V^- = −12V		19.0	25.0	mA
		V^+ = 15V, V^- = −15V		25.0	34.0	mA
	V_{IN} = 0.8V	V^+ = 9.0V, V^- = −9.0V		4.5	6.0	mA
		V^+ = 12V, V^- = −12V		5.5	7.0	mA
		V^+ = 15V, V^- = −15V		8.0	12.0	mA
Negative Supply Current (Output Open)	V_{IN} = 1.9V	V^+ = 9.0V, V^- = −9.0V		−13.0	−17.0	mA
		V^+ = 12V, V^- = −12V		−18.0	−23.0	mA
		V^+ = 15V, V^- = −15V		−25.0	−34.0	mA
	V_{IN} = 0.8V	V^+ = 9.0V, V^- = −9.0V		−.001	−1.0	mA
		V^+ = 12V, V^- = −12V		−.001	−1.0	mA
		V^+ = 15V, V^- = −15V		−.01	−2.5	mA
Power Dissipation	V^+ = 9.0V, V^- = −9.0V			252	333	mW
	V^+ = 12V, V^- = −12V			444	576	mW
Propagation Delay to "1" (t_{pd1})	R_L = 3.0 kΩ C_L = 15 pF, T_A = 25°C			230	300	ns
Propagation Delay to "0" (t_{pd0})	R_L = 3.0 kΩ C_L = 15 pF, T_A = 25°C			70	175	ns
Rise Time (t_r)	R_L = 3.0 kΩ C_L = 15 pF, T_A = 25°C			75	100	ns
Fall Time (t_f)	R_L = 3.0 kΩ C_L = 15 pF, T_A = 25°C			40	75	ns

Note 1: Voltage values shown are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: The maximum junction temperature of the LM1488 is 150°C. For operating at elevated temperatures the cavity Dual-In-Line Package (J) must be derated based on a thermal resistance of 85°C/W, junction to ambient.

Note 3: These specifications apply for V^+ = +9.0V ± 1%, V^- = −9.0V ± 1%, T_A = 0°C to +75°C unless otherwise noted. All typicals are for V^+ = 9.0V, V^- = −9.0V, and T_A = 25°C.

applications

By connecting a capacitor to each driver output the slew rate can be controlled utilizing the output current limiting characteristics of the LM1488. For a set slew rate the appropriate capacitor value may be calculated using the following relationship

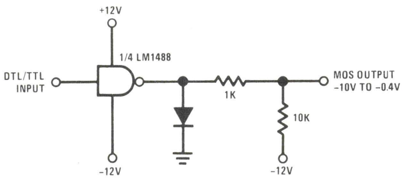
$$C = I_{SC}\,(\Delta T/\Delta V)$$

where C is the required capacitor, I_{SC} is the short circuit current value, and $\Delta V/\Delta T$ is the slew rate.

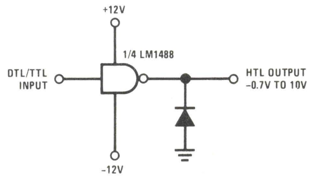
RS232C specifies that the output slew rate must not exceed 30V per microsecond. Using the worst case output short circuit current of 12 mA in the above equation, calculations result in a required capacitor of 400 pF connected to each output.

typical applications (con't)

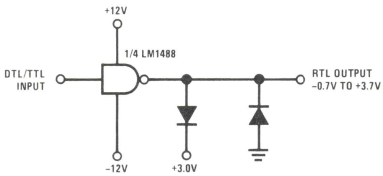
DTL/TTL-to-MOS Translator



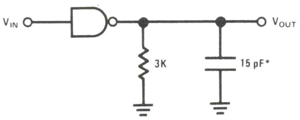
DTL/TTL-to-HTL Translator



DTL/TTL-to-RTL Translator

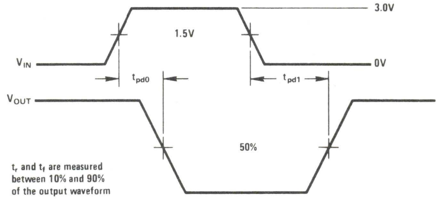


ac load circuit



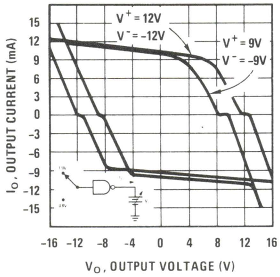
*C_L includes probe and jig capacitance.

switching time waveforms



typical performance characteristics

Output Voltage and Current-Limiting Characteristics



Interface Circuits

LM1489/LM1489A quad line receiver

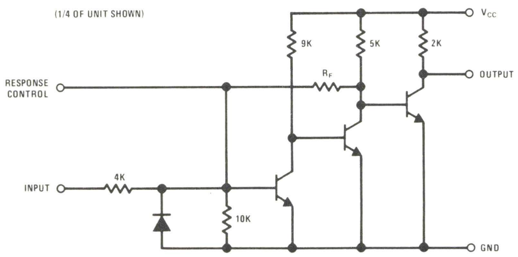
general description

The LM1489/LM1489A are quad line receivers designed to interface data terminal equipment with data communications equipment. They are constructed on a single monolithic silicon chip. These devices satisfy the specifications of EIA standard No. RS232C. The LM1489/LM1489A meet and exceed the specifications of MC1489/MC1489A and are pin-for-pin replacements. The LM1489/LM1489A are available in 14 lead ceramic dual-in-line package.

features

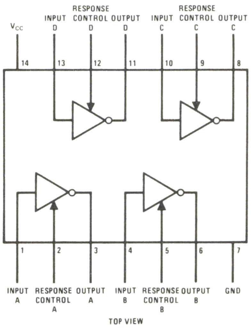
- Four totally separate receivers per package
- Programmable threshold
- Built-in input threshold hysteresis
- "Fail safe" operating mode
- Inputs withstand ±30V

schematic and connection diagrams



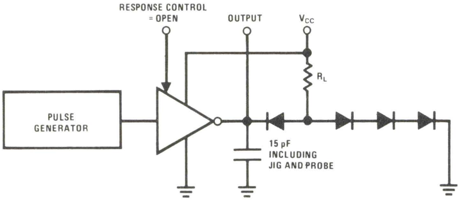
LM1489: R_F = 10K
LM1489A: R_F = 2K

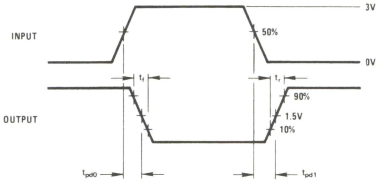
Dual-In-Line Package



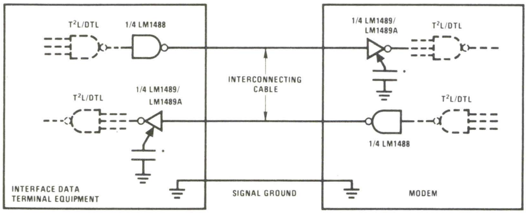
Order Number LM1489J or LM1489AJ
See Package 16

ac test circuit and voltage waveforms



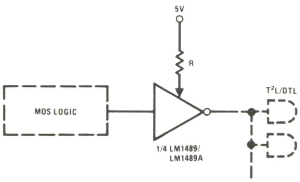


typical applications



*OPTIONAL FOR NOISE FILTERING

RS232C Data Transmission



MOS to T^2L/DTL Translator

absolute maximum ratings (Note 1)

The following apply for $T_A = 25^\circ C$ unless otherwise specified.

Power Supply Voltage	10V	Power Dissipation (Note 2)	1W
Input Voltage Range	±30V	Operating Temperature Range	0°C to +75°C
Output Load Current	20 mA	Storage Temperature Range	−65°C to +175°C

electrical characteristics (Note 3)

LM1489/LM1489A: The following apply for $V_{CC} = 5.0V \pm 1\%$, $0^\circ C \le T_A \le +75^\circ C$ unless otherwise specified.

PARAMETER	CONDITIONS	LM1489			LM1489A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input High Threshold Voltage	$T_A = 25^\circ C$, $V_{OUT} \le 0.45V$, $I_{OUT} = 10$ mA	1.0		1.5	1.75		2.25	V
Input Low Threshold Voltage	$T_A = 25^\circ C$, $V_{OUT} \ge 2.5V$, $I_{OUT} = -0.5$ mA	0.75		1.25	0.75		1.25	V
Input Current	$V_{IN} = +25V$	+3.6	+5.6	+8.3	+3.6	+5.6	+8.3	mA
	$V_{IN} = -25V$	−3.6	−5.6	−8.3	−3.6	−5.6	−8.3	
	$V_{IN} = +3V$	+0.43	+0.53		+0.43	+0.53		mA
	$V_{IN} = -3V$	−0.43	−0.53		−0.43	−0.53		
Output High Voltage	$V_{IN} = 0.75V$, $I_{OUT} = -0.5$ mA	2.6	3.8	5.0	2.6	3.8	5.0	V
	Input = Open, $I_{OUT} = -0.5$ mA	2.6	3.8	5.0	2.6	3.8	5.0	V
Output Low Voltage	$V_{IN} = 3.0V$, $I_{OUT} = 10$ mA		0.33	0.45		0.33	0.45	V
Output Short Circuit Current	$V_{IN} = 0.75V$		3.0			3.0		mA
Supply Current	$V_{IN} = 5.0V$		14	26		14	26	mA
Power Dissipation	$V_{IN} = 5.0V$		70	130		70	130	mW
LM1489/LM1489A: The following apply for $V_{CC} = 5.0V \pm 1\%$, $T_A = 25^\circ C$								
Input to Output "High" Propagation Delay (t_{pd1})	$R_L = 3.9k$ (Figure 1) (AC Test Circuit)		28	85		28	85	ns
Input to Output "Low" Propagation Delay (t_{pd0})	$R_L = 390\Omega$ (Figure 1) (AC Test Circuit)		20	50		20	50	ns
Output Rise Time	$R_L = 3.9k$ (Figure 1) (AC Test Circuit)		110	175		110	175	ns
Output Fall Time	$R_L = 390\Omega$ (Figure 1) (AC Test Circuit)		9	20		9	20	ns

Note 1: Voltage values shown are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: For operation at elevated temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of 85°C/W junction to case.

Note 3: These specifications apply for response control pin = open.

Interface Circuits

LM55107A/LM75107A, LM55108A/LM75108A, LM163/LM363 dual line receivers LM75207, LM75208, LM363A dual MOS sense amplifiers

general description

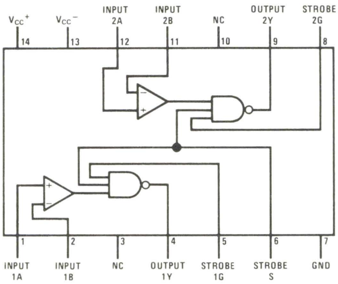
The nine products described herein are TTL compatible dual high speed circuits intended for sensing in a broad range of system applications. While the primary usage will be for line receivers or MOS sensing, any of the products may effectively be used as voltage comparators, level translators, window detectors, transducer preamplifiers, and in other sensing applications. As digital line receivers the products are applicable with the LM55109/LM75109 and LM55110/LM75110 companion drivers, or may be used in other balanced or unbalanced party-line data transmission systems. The improved input sensitivity and delay specifications of the LM75207, LM75208 and LM363A make them ideal for sensing high performance MOS memories as well as high sensitivity line receivers and voltage comparators. TRI-STATE® products enhance bused organizations.

features

- High speed 17 ns typ
- TTL compatible
- Input sensitivity ±10 mV or ±25 mV
- Input common-mode range ±3V
- High input impedance with normal V_{CC}, or V_{CC} = 0V
- Strobes for channel selection
- TRI-STATE outputs for high speed buses
- Dual circuits
- Sensitivity guaranteed over full common-mode range
- Logic input clamp diodes
- 14 pin cavity or molded dual-in-line package
- Standard supply voltages ±5V

connection diagrams

Dual-In-Line Package

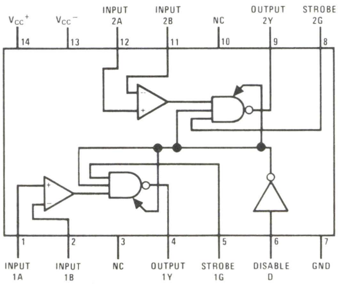


TOP VIEW

Order Number:
LM55107AJ
LM75107AJ
LM55108AJ
LM75108AJ
LM75207J
LM75208J
See Package 16

Order Number:
LM75107AN
LM75108AN
LM75207N
LM75208N
See Package 22

Dual-In-Line Package



TOP VIEW

Order Number:
LM163J
LM363J
LM363AJ
See Package 16

Order Number:
LM363N
LM363AN
See Package 22

product selection guide

TEMPERATURE→ / PACKAGE→	$-55°C \le T_A \le +125°C$ CAVITY DIP	$0°C \le T_A \le +70°C$ CAVITY OR MOLDED DIP	
INPUT SENSITIVITY→ / OUTPUT LOGIC↓	±25 mV	±25 mV	±10 mV
TTL Active Pull-up	LM55107A	LM75107A	LM75207
TTL Open Collector	LM55108A	LM75108A	LM75208
TTL TRI-STATE	LM163	LM363	LM363A

absolute maximum ratings

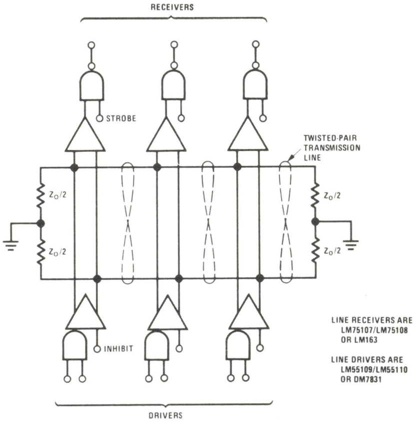
Supply Voltage, V_{CC}^+	7V
Supply Voltage, V_{CC}^-	−7V
Differential Input Voltage	±6V
Common Mode Input Voltage	±5V
Strobe Input Voltage	5.5V
Storage Temperature Range	−65°C to +150°C
Power Dissipation	600 mW
Lead Temperature (Soldering, 10 sec)	300°C

operating conditions

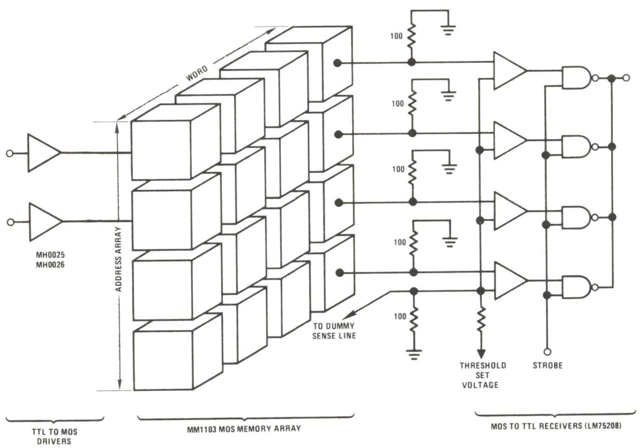
	LM55107A, LM55108A, LM163			LM75107A, LM75207 LM75108A, LM75208 LM363, LM363A		
	MIN	NOM	MAX	MIN	NOM	MAX
Supply Voltage V_{CC}^+	4.5V	5V	5.5V	4.75V	5V	5.25V
Supply Voltage V_{CC}^-	−4.5V	−5V	−5.5V	−4.75V	−5V	−5.25V
Operating Temperature Range	−55°C	to	+125°C	0°C	to	+70°C

typical applications

Line Receiver Used in a Party-Line or Data-Bus System

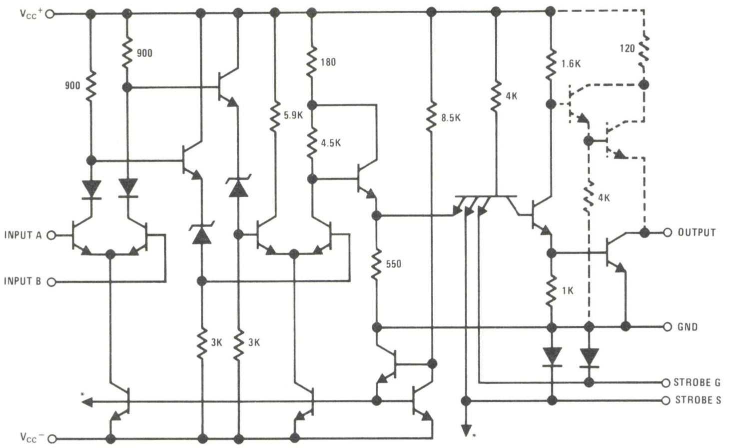


Line Receiver Used in MOS Memory System



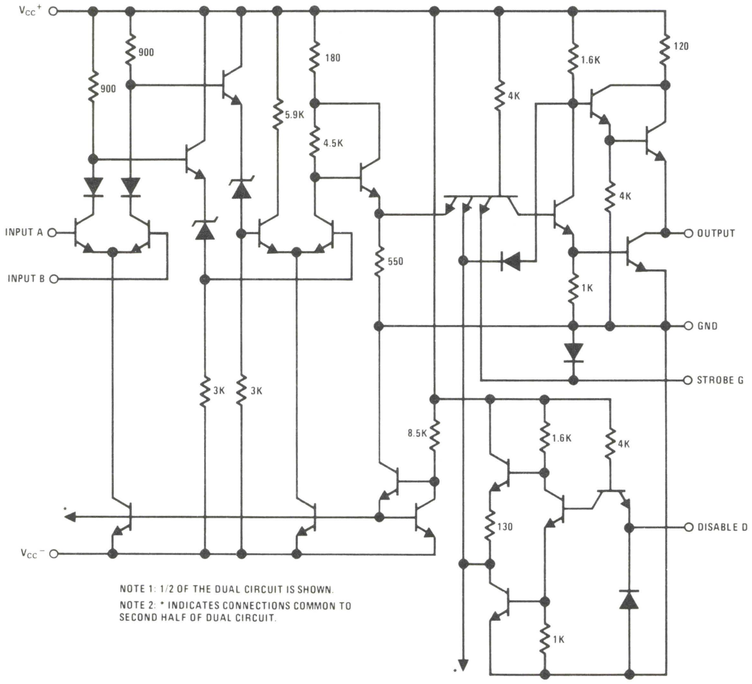
schematic diagrams

LM55107A/LM75107A, LM75207
LM55108A/LM75108A, LM75208



NOTE 1: 1/2 OF THE DUAL CIRCUIT IS SHOWN.
NOTE 2: * INDICATES CONNECTIONS COMMON TO SECOND HALF OF DUAL CIRCUIT.
NOTE 3: COMPONENTS SHOWN WITH DASH LINES ARE APPLICABLE TO THE LM55107A, LM75107A, AND LM75207 ONLY.

LM163/LM363, LM363A



NOTE 1: 1/2 OF THE DUAL CIRCUIT IS SHOWN.
NOTE 2: * INDICATES CONNECTIONS COMMON TO SECOND HALF OF DUAL CIRCUIT.

LM55107A/LM75107A, LM55108A/LM75108A

dc electrical characteristics ($T_{MIN} \leq T_A \leq T_{MAX}$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55107A/LM75107A			LM55108A/LM75108A			
		MIN	TYP	MAX	MIN	TYP	MAX	
High Level Input Current Into 1A, 1B, 2A or 2B (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 0.5V, V_{IC} = −3V to 3V		30	75		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = −2V, V_{IC} = −3V to 3V			−10			−10	μA
High Level Input Current Into 1G or 2G (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			40			40	μA
High Level Input Current Into 1G or 2G (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			1			1	mA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(S)}$ = 0.4V			−1.6			−1.6	mA
High Level Input Current Into S (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			80			80	μA
High Level Input Current Into S (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			2			2	mA
Low Level Input Current Into S (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(S)}$ = 0.4V			−3.2			−3.2	mA
High Level Output Voltage (V_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{LOAD} = −400μA, V_{ID} = 25 mV, V_{IC} = −3V to 3V	2.4						V
Low Level Output Voltage (V_{OL})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{SINK} = 16 mA, V_{ID} = −25 mV, V_{IC} = −3V to 3V			0.4			0.4	V
High Level Output Current (I_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min V_{OH} = Max V_{CC}^+						250	μA
Short Circuit Output Current (I_{OS})	V_{CC}^+ = Max, V_{CC}^- = Max	−18		−70				mA
High Logic Level Supply Current From V_{CC} (I_{CCH}^+)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 25 mV, T_A = 25°C		18	30		18	30	mA
High Logic Level Supply Current From V_{CC} (I_{CCH}^-)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 25 mV, T_A = 25°C		−8.4	−15		−8.4	−15	mA
Input Clamp Voltage on G or S (V_I)	V_{CC}^+ = Min, V_{CC}^- = Min, I_{IN} = −12 mA, T_A = 25°C		−1	−1.5		−1	−1.5	V

ac switching characteristics (V_{CC}^+ = 5V, V_{CC}^- = −5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55107A/LM75107A			LM55108A/LM75108A			
		MIN	TYP	MAX	MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 390Ω, C_L = 50 pF		17	25				ns
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 390Ω, C_L = 15 pF					19	25	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) ($t_{PHL(D)}$)	R_L = 390Ω, C_L = 50 pF		17	25				ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) ($t_{PHL(D)}$)	R_L = 390Ω, C_L = 15 pF					19	25	ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output ($t_{PLH(S)}$)	R_L = 390Ω, C_L = 50 pF		10	15				ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output ($t_{PLH(S)}$)	R_L = 390Ω, C_L = 15 pF					13	20	ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output ($t_{PHL(S)}$)	R_L = 390Ω, C_L = 50 pF		8	15				ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output ($t_{PHL(S)}$)	R_L = 390Ω, C_L = 15 pF					13	20	ns

Note 1: Differential input is +100 mV to −100 mV pulse. Delays read from 0 mV on input to 1.5V on output.

LM75207, LM75208

dc electrical characteristics ($0°C \leq T_A \leq +70°C$)

PARAMETER	CONDITIONS	LIMITS LM75207 MIN	LM75207 TYP	LM75207 MAX	LM75208 MIN	LM75208 TYP	LM75208 MAX	UNITS
High Level Input Current Into 1A, 1B, 2A or 2B (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 0.5V, V_{IC} = −3V to 3V		30	75		30	75	µA
Low Level Input Current Into 1A, 1B, 2A or 2B (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = −2V, V_{IC} = −3V to 3V			−10			−10	µA
High Level Input Current Into 1G or 2G (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			40			40	µA
High Level Input Current Into 1G or 2G (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			1			1	mA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(S)}$ = 0.4V			−1.6			−1.6	mA
High Level Input Current Into S (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			80			80	µA
High Level Input Current Into S (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			2			2	mA
Low Level Input Current Into S (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(S)}$ = 0.4V			−3.2			−3.2	mA
High Level Output Voltage (V_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{LOAD} = −400µA, V_{ID} = 10 mV, V_{IC} = −3V to 3V	2.4						V
Low Level Output Voltage (V_{OL})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{SINK} = 16 mA, V_{ID} = −10 mV, V_{IC} = −3V to 3V			0.4			0.4	V
High Level Output Current (I_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min V_{OH} = Max V_{CC}^+						250	µA
Short Circuit Output Current (I_{OS})	V_{CC}^+ = Max, V_{CC}^- = Max	−18		−70				mA
High Logic Level Supply Current From V_{CC} (I_{CCH}^+)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 10 mV, T_A = 25°C		18	30		18	30	mA
High Logic Level Supply Current From V_{CC} (I_{CCH}^-)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 10 mV, T_A = 25°C		−8.4	−15		−8.4	−15	mA
Input Clamp Voltage on G or S (V_I)	V_{CC}^+ = Min, V_{CC}^- = Min, I_{IN} = −12 mA, T_A = 25°C		−1	−1.5		−1	−1.5	V

ac switching characteristics ($V_{CC}^+ = 5V$, $V_{CC}^- = -5V$, $T_A = 25°C$)

PARAMETER	CONDITIONS	LIMITS LM75207 MIN	LM75207 TYP	LM75207 MAX	LM75208 MIN	LM75208 TYP	LM75208 MAX	UNITS
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 470Ω, C_L = 15 pF			35				ns
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 470Ω, C_L = 15 pF						35	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to output (Note 1) ($t_{PHL(D)}$)	R_L = 470Ω, C_L = 15 pF			20				ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) ($t_{PHL(D)}$)	R_L = 470Ω, C_L = 15 pF						20	ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output ($t_{PLH(S)}$)	R_L = 470Ω, C_L = 15 pF			17				ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output ($t_{PLH(S)}$)	R_L = 470Ω, C_L = 15 pF						17	ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output ($t_{PHL(S)}$)	R_L = 470Ω, C_L = 15 pF			17				ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output ($t_{PHL(S)}$)	R_L = 470Ω, C_L = 15 pF						17	ns

Note 1: Differential input is +10 mV to −30 mV pulse. Delays read from 0 mV on input to 1.5V on output.

LM163/LM363

dc electrical characteristics ($T_{MIN} \leq T_A \leq T_{MAX}$)

PARAMETER	CONDITIONS	LIMITS LM163/LM363 MIN	TYP	MAX	UNITS
High Level Input Current Into 1A, 1B, 2A or 2B (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 0.5V, V_{IC} = −3V to 3V		30	75	µA
Low Level Input Current Into 1A, 1B, 2A or 2B (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = −2V, V_{IC} = −3V to 3V			−10	µA
High Level Input Current Into 1G, 2G or D (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			40	µA
High Level Input Current Into 1G, 2G or D (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			1	mA
Low Level Input Current Into D (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(D)}$ = 0.4V			−1.6	mA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, $V_{IL(G)}$ = 0.4V			−40	µA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(D)}$ = 0.8V, $V_{IL(G)}$ = 0.4V			−1.6	mA
High Level Output Voltage (V_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{LOAD} = −2 mA, V_{ID} = 25 mV, $V_{IL(D)}$ = 0.8V, V_{IC} = −3V to 3V	2.4			V
Low Level Output Voltage (V_{OL})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{SINK} = 16 mA, V_{ID} = −25 mV, $V_{IL(D)}$ = 0.8V, V_{IC} = −3V to 3V			0.4	V
Output Disable Current (I_{OD})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, V_{OUT} = 2.4V			40	µA
Output Disable Current (I_{OD})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, V_{OUT} = 0.4V			−40	µA
Short Circuit Output Current (I_{OS})	V_{CC}^+ = Max, $V_{IL(D)}$ = 0.8V, V_{CC}^- = Max	−18		−70	mA
High Logic Level Supply Current From V_{CC}^+ (I_{CCH}^+)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 25 mV, T_A = 25°C		28	40	mA
High Logic Level Supply Current From V_{CC}^- (I_{CCH}^-)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 25 mV, T_A = 25°C		−8.4	−15	mA
Input Clamp Voltage on G or D (V_I)	V_{CC}^+ = Min, V_{CC}^- = Min, I_{IN} = −12 mA, T_A = 25°C		−1	−1.5	V

ac switching characteristics (V_{CC}^+ = 5V, V_{CC}^- = −5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS LM163/LM363 MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 390Ω, C_L = 50 pF		17	25	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) ($t_{PHL(D)}$)	R_L = 390Ω, C_L = 50 pF		17	25	ns
Propagation Delay Time, Low to High Level, From Strobe Input G to Output ($t_{PLH(S)}$)	R_L = 390Ω, C_L = 50 pF		10	15	ns
Propagation Delay Time, High to Low Level, From Strobe Input G to Output ($t_{PHL(S)}$)	R_L = 390Ω, C_L = 50 pF		8	15	ns
Disable Low to High to Output High to Off (t_{1H})	R_L = 390Ω, C_L = 5 pF			20	ns
Disable Low to High to Output Low to Off (t_{0H})	R_L = 390Ω, C_L = 5 pF			30	ns
Disable High to Low to Output Off to High (t_{H1})	R_L = 1k to 0V, C_L = 50 pF			25	ns
Disable High to Low to Output Off to Low (t_{H0})	R_L = 390Ω, C_L = 50 pF			25	ns

Note 1: Differential input is +100 mV to −100 mV pulse. Delays read from 0 mV on input to 1.5V on output.

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LM363A

dc electrical characteristics ($0°C \le T_A \le +70°C$)

PARAMETER	CONDITIONS	LIMITS LM363A MIN	TYP	MAX	UNITS
High Level Input Current Into 1A, 1B, 2A or 2B (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 0.5V, V_{IC} = −3V to 3V		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = −2V, V_{IC} = −3V to 3V			−10	μA
High Level Input Current Into 1G, 2G or D (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = 2.4V			40	μA
High Level Input Current Into 1G, 2G or D (I_{IH})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(S)}$ = Max V_{CC}^+			1	mA
Low Level Input Current Into D (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(D)}$ = 0.4V			−1.6	mA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, $V_{IL(G)}$ = 0.4V			−40	μA
Low Level Input Current Into 1G or 2G (I_{IL})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IL(D)}$ = 0.8V, $V_{IL(G)}$ = 0.4V			−1.6	mA
High Level Output Voltage (V_{OH})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{LOAD} = −2 mA, V_{ID} = 10 mV, $V_{IL(D)}$ = 0.8V, V_{IC} = −3V to 3V	2.4			V
Low Level Output Voltage (V_{OL})	V_{CC}^+ = Min, V_{CC}^- = Min, I_{SINK} = 16 mA, V_{ID} = −10 mV, $V_{IL(D)}$ = 0.8V, V_{IC} = −3V to 3V			0.4	V
Output Disable Current (I_{OD})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, V_{OUT} = 2.4V			40	μA
Output Disable Current (I_{OD})	V_{CC}^+ = Max, V_{CC}^- = Max, $V_{IH(D)}$ = 2V, V_{OUT} = 0.4V			−40	μA
Short Circuit Output Current (I_{OS})	V_{CC}^+ = Max, $V_{IL(D)}$ = 0.8V, V_{CC}^- = Max	−18		−70	mA
High Logic Level Supply Current From V_{CC}^+ (I_{CCH}^+)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 10 mV, T_A = 25°C		28	40	mA
High Logic Level Supply Current From V_{CC}^- (I_{CCH}^-)	V_{CC}^+ = Max, V_{CC}^- = Max, V_{ID} = 10 mV, T_A = 25°C		−8.4	−15	mA
Input Clamp Voltage on G or D (V_I)	V_{CC}^+ = Min, V_{CC}^- = Min, I_{IN} = −12 mA, T_A = 25°C		−1	−1.5	V

ac switching characteristics (V_{CC}^+ = 5V, V_{CC}^- = −5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS LM363A MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) ($t_{PLH(D)}$)	R_L = 470Ω, C_L = 15 pF			35	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) ($t_{PHL(D)}$)	R_L = 470Ω, C_L = 15 pF			20	ns
Propagation Delay Time, Low to High Level, From Strobe Input G to Output ($t_{PLH(S)}$)	R_L = 470Ω, C_L = 15 pF			17	ns
Propagation Delay Time, High to Low Level, From Strobe Input G to Output ($t_{PHL(S)}$)	R_L = 470Ω, C_L = 15 pF			17	ns
Disable Low to High to Output High to Off (t_{1H})	R_L = 470Ω, C_L = 5 pF			20	ns
Disable Low to High to Output Low to Off (t_{0H})	R_L = 470Ω, C_L = 5 pF			30	ns
Disable High to Low to Output Off to High (t_{H1})	R_L = 1k to 0V, C_L = 15 pF			25	ns
Disable High to Low to Output Off to Low (t_{H0})	R_L = 470Ω, C_L = 15 pF			25	ns

Note 1: Differential input is +10 mV to −30 mV pulse. Delays read from 0 mV on input to 1.5V on output.

Interface Circuits

LM55109/LM75109, LM55110/LM75110 dual line drivers

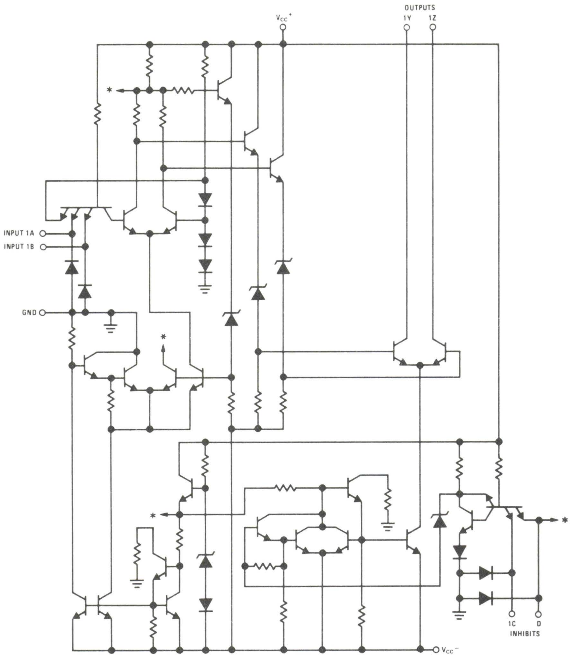
general description

These products are TTL compatible high speed differential line drivers intended for use in terminated twisted-pair party-line data transmission systems. They may also be used for level shifting since output common-mode range is −3V to +10V. An internal current sink is switched to either output dependent on input logic conditions. The current sink may be turned off by appropriate inhibit input conditions.

features

- Tightly controlled output currents over temperature, V_{CC}, and common-mode variations
- High speed 15 ns max
- Wide output common-mode range
- High output impedance
- Inhibits for party-line applications
- Current sink outputs 6 or 12 mA
- Dual circuits
- Standard supply voltages ±5V
- Input clamp diodes
- 14 pin cavity or molded DIP

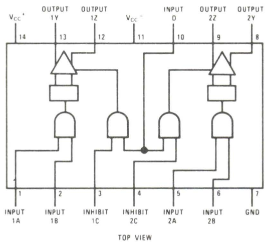
schematic diagram



NOTE 1: 1/2 OF THE DUAL CIRCUIT SHOWN.
NOTE 2: *INDICATES CONNECTIONS COMMON TO SECOND HALF OF CIRCUIT.

connection diagram

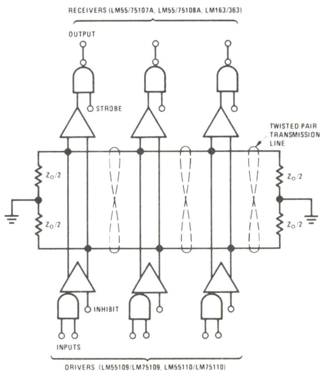
Dual-In-Line Package



Order Number LM55109J, LM55110J, LM75109J, or LM75110J
See Package 16
or
Order Number LM75109N or LM75110N
See Package 22

typical application

Party-Line Data Transmission System



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absolute maximum ratings

Supply Voltage, $V_{CC}{}^+$	7V
Supply Voltage, $V_{CC}{}^-$	−7V
Logic and Inhibitor Input Voltages	5.5V
Common-mode Output Voltage	−5V to 12V
Storage Temperature Range	−65°C to +150°C
Power Dissipation	600 mW
Operating Temperature Range	
LM55109/LM55110	−55°C to +125°C
LM75109/LM75110	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics ($T_{MIN} \le T_A \le T_{MAX}$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55109/LM75109			LM55110/LM75110			
		MIN	TYP	MAX	MIN	TYP	MAX	
Operating Conditions								
Supply Voltage $V_{CC}{}^+$		4.5	5	5.5	4.75	5	5.25	V
Supply Voltage $V_{CC}{}^-$		−4.5	−5	−5.5	−4.75	−5	−5.25	V
Positive Common Mode Output Voltage		0		10	0		10	V
Negative Common Mode Output Voltage		0		−3	0		−3	V
High Level Input Current Into 1A, 1B, 2A or 2B ($I_{IH(L)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(L)}$ = 2.4V			40			40	µA
High Level Input Current Into 1A, 1B, 2A or 2B ($I_{IH(L)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(L)}$ = Max $V_{CC}{}^+$			1			1	mA
Low Level Input Current Into 1A, 1B, 2A or 2B ($I_{IL(L)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IL(L)}$ = 0.4V			−3			−3	mA
High Level Input Current Into 1C or 2C ($I_{IH(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(I)}$ = 2.4V			40			40	µA
High Level Input Current Into 1C or 2C ($I_{IH(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(I)}$ = Max $V_{CC}{}^+$			1			1	mA
Low Level Input Current Into 1C or 2C ($I_{IL(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IL(I)}$ = 0.4V			−3			−3	mA
High Level Input Current Into D ($I_{IH(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(I)}$ = 2.4V			80			80	µA
High Level Input Current Into D ($I_{IH(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IH(I)}$ = Max $V_{CC}{}^+$			2			2	mA
Low Level Input Current Into D ($I_{IL(I)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{IL(I)}$ = 0.4V			−6			−6	mA
On State Output Current ($I_{O(ON)}$)	$V_{CC}{}^+$ = Max, $V_{CC}{}^-$ = Max, $V_{CC}{}^+$ = Min, $V_{CC}{}^-$ = Max	 3.5		7 	 6.5		15 	mA mA
Off State Output Current ($I_{O(OFF)}$)	$V_{CC}{}^+$ = Min, $V_{CC}{}^-$ = Min			100			100	µA
Supply Current From $V_{CC}{}^+$ With Driver Enabled ($I_{CC}{}^+{}_{(ON)}$)	$V_{IL(L)}$ = 0.4V, $V_{IH(I)}$ = 2V		18	30		23	35	mA
Supply Current From $V_{CC}{}^-$ With Driver Enabled ($I_{CC}{}^-{}_{(ON)}$)	$V_{IL(L)}$ = 0.4V, $V_{IH(I)}$ = 2V		−18	−30		−34	−50	mA
Supply Current From $V_{CC}{}^+$ With Driver Inhibited ($I_{CC}{}^+{}_{(OFF)}$)	$V_{IL(L)}$ = 0.4V, $V_{IL(I)}$ = 0.4V		18			21		mA
Supply Current From $V_{CC}{}^-$ With Driver Inhibited ($I_{CC}{}^-{}_{(OFF)}$)	$V_{IL(L)}$ = 0.4V, $V_{IL(I)}$ = 0.4V		−10			−17		mA
Input Clamp Voltage on Inputs or Inhibits (V_I)	$V_{CC}{}^+$ = Min, $V_{CC}{}^-$ = Min, I_{IN} = −12 mA, T_A = 25°C		−1	−1.5		−1	−1.5	V

ac switching characteristics ($V_{CC}^+ = 5V$, $V_{CC}^- = 5V$, $T_A = 25°C$)

PARAMETER	CONDITIONS	LIMITS LM55109/LM75109 MIN	TYP	MAX	LM55110/LM75110 MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level, From Logic Input A or B to Output Y or Z ($t_{PLH(L)}$)	$R_L = 50\Omega$, $C_L = 40$ pF		9	15		9	15	ns
Propagation Delay Time, High to Low Level, From Logic Input A or B to Output Y or Z ($t_{PHL(L)}$)	$R_L = 50\Omega$, $C_L = 40$ pF		9	15		9	15	ns
Propagation Delay Time, Low to High Level, From Inhibitor Input C or D to Output Y or Z ($t_{PLH(I)}$)	$R_L = 50\Omega$, $C_L = 40$ pF		16	25		16	25	ns
Propagation Delay Time, High to Low Level, From Inhibitor Input C or D to Output Y or Z ($t_{PHL(I)}$)	$R_L = 50\Omega$, $C_L = 40$ pF		13	25		13	25	ns

Interface Circuits

LM75324 memory driver with decode inputs

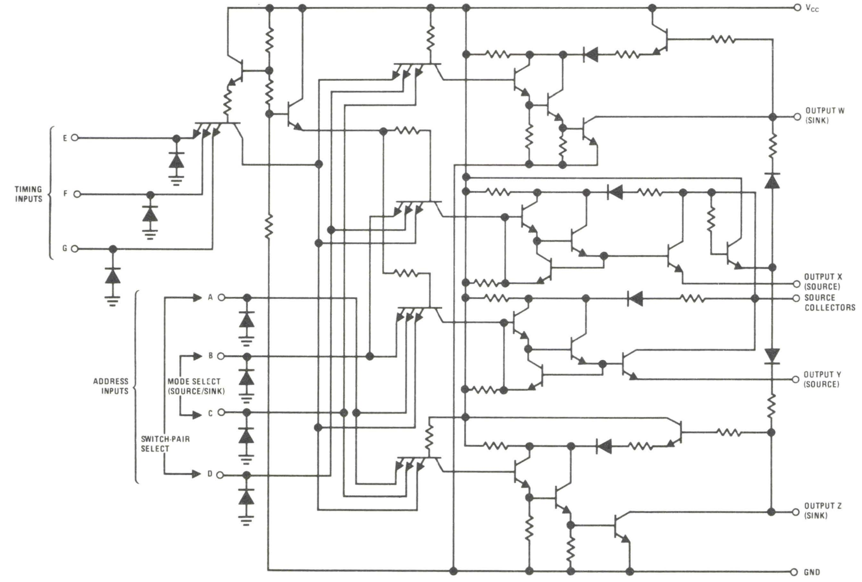
general description

The LM75324 is a monolithic memory driver which features two 400 mA (source/sink) switch pairs along with decoding capability from four address lines. Inputs B and C function as mode selection lines (source or sink) while lines A and D are used for switch-pair selection (output pair Y/Z or W/X).

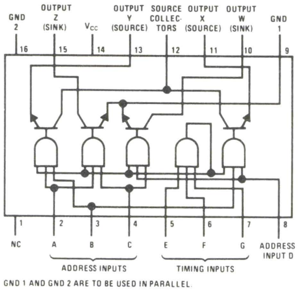
features

- Output capability 400 mA
- High voltage outputs
- Dual sink/source outputs
- Internal decoding and timing circuitry
- Fast switching times
- Operation 0°C to +70°C
- DTL/TTL compatible
- Input clamping diodes

schematic and connection diagrams



Dual-In-Line Package (J)

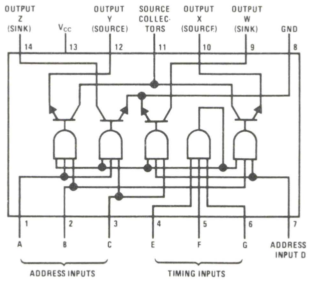


GND 1 AND GND 2 ARE TO BE USED IN PARALLEL.

TOP VIEW

Order Number LM75324J
See Package 17

Dual-In-Line Package (N)



TOP VIEW

Order Number LM75324N
See Package 22

absolute maximum ratings

Supply Voltage V_{CC} (Note 1)	17V
Input Voltage (Note 2)	5.5V
Operating Case Temperature Range	0°C to +70°C
Continuous Total Power Dissipation at (or Below) +70°C Case Temperature	800 mW
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (V_{CC} = 14V, T_C = 0°C to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Required to Insure Logical "1" At Any Input ($V_{IN(1)}$)	Figure 1	3.5			V
Input Voltage Required to Insure Logical "0" At Any Input ($V_{IN(0)}$)	Figure 1			0.8	V
Logical "1" Level Address Input Current ($I_{IN(1)}$)	V_{IN} = 5V, Figure 1			200	μA
Logical "1" Level Timing Input Current ($I_{IN(1)}$)	V_{IN} = 5V, Figure 1			100	μA
Logical "0" Level Address Input Current ($I_{IN(0)}$)	V_{IN} = 0V, Figure 1			−6	mA
Logical "0" Level Timing Input Current ($I_{IN(0)}$)	V_{IN} = 0V, Figure 1			−12	mA
Sink Saturation Voltage (V_{sat})	I_{SINK} ≃ 420 mA, R_L = 53Ω, Figure 2		0.75	0.85	V
Source Saturation Voltage (V_{sat})	I_{SOURCE} ≃ −420 mA, R_L = 47.5Ω, Figure 2		0.75	0.85	V
Output Reverse Current (Off State) (I_{OFF})	V_{IN} = 0V, Figure 1		125	200	μA
Supply Current, All Sources and Sinks Off (I_{CC})	V_{IN} = 0V, Figure 3		12.5	15	mA
Supply Current, Either Sink Selected (I_{CC})	Figure 4		30	40	mA
Supply Current, Either Source Selected (I_{CC})	Figure 4		25	35	mA
Input Clamp Voltage (V_1)	I_{IN} = −12 mA, T_A = 25°C			−1.5	V

ac switching characteristics (V_{CC} = 14V, T_C = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time to Logical "1" Level, Source Output (t_{pd1})	R_{L1} = 53Ω, R_{L2} = 500Ω, C_L = 20 pF, Figure 5			90	ns
Propagation Delay Time to Logical "0" Level, Source Output (t_{pd0})				50	ns
Propagation Delay Time to Logical "1" Level, Sink Output (t_{pd1})	R_L = 53Ω, C_L = 20 pF, Figure 6			110	ns
Propagation Delay Time to Logical "0" Level, Sink Output (t_{pd0})				40	ns
Sink Storage Time (t_s)				70	ns

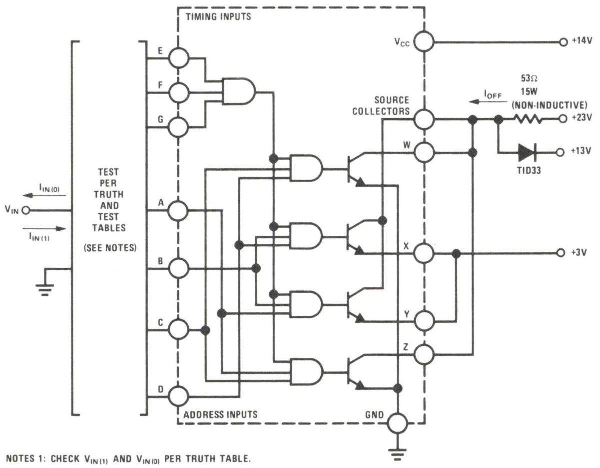
Note 1: Voltage values are with respect to network ground terminal.

Note 2: Input signals must be zero or positive with respect to network ground terminal.

truth table

INPUTS							OUTPUTS			
ADDRESS				TIMING			SINK	SOURCES		SINK
A	B	C	D	E	F	G	W	X	Y	Z
0	0	1	1	1	1	1	ON	OFF	OFF	OFF
0	1	0	1	1	1	1	OFF	ON	OFF	OFF
1	1	0	0	1	1	1	OFF	OFF	ON	OFF
1	0	1	0	1	1	1	OFF	OFF	OFF	ON
X	X	X	X	0	X	X	OFF	OFF	OFF	OFF
X	X	X	X	X	0	X	OFF	OFF	OFF	OFF
X	X	X	X	X	X	0	OFF	OFF	OFF	OFF

test circuits and switching time waveforms



NOTES 1: CHECK $V_{IN(1)}$ AND $V_{IN(0)}$ PER TRUTH TABLE.

NOTES 2: MEASURE $I_{IN(0)}$ PER TEST TABLE.

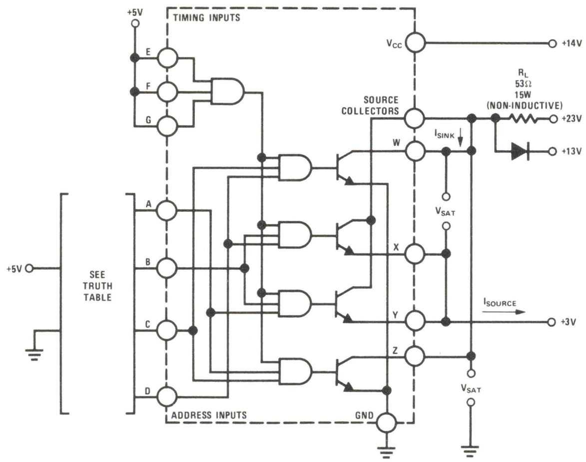
NOTES 3: WHEN MEASURING $I_{IN(1)}$, ALL OTHER INPUTS ARE AT GND. EACH INPUT IS TESTED SEPARATELY.

TEST TABLE FOR $I_{IN(0)}$

APPLY 3.5V	GROUND	TEST $I_{IN(0)}$
B, C, E, F, and G	A and D	A
B, C, E, F, and G	A and D	D
A, D, E, F, and G	B and C	B
A, D, E, F, and G	B and C	C
A, B, C, D, F, and G	E	E
A, B, C, D, E, and G	F	F
A, B, C, D, E, and F	G	G

FIGURE 1. $V_{IN(0)}$, $V_{IN(1)}$, $I_{IN(0)}$, $I_{IN(1)}$, and I_{OFF}

test circuits and switching time waveforms (con't)



NOTE: THIS PARAMETER MUST BE MEASURED USING PULSE TECHNIQUES. t_P = 500 ns, duty cycle ≤ 1%.

FIGURE 2. $V_{(SAT)}$

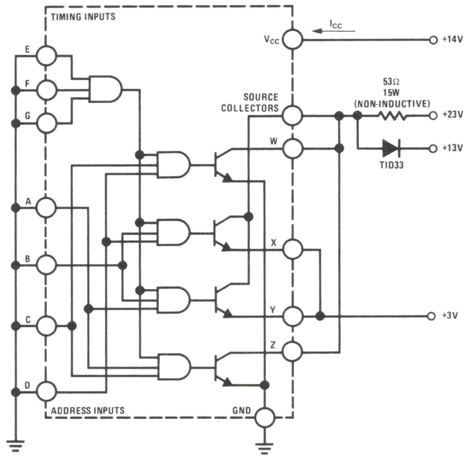
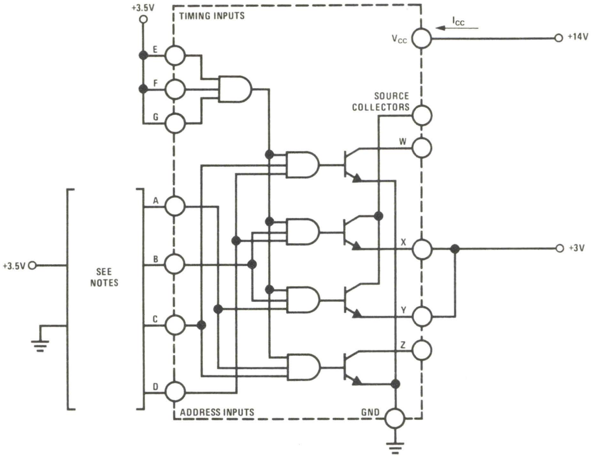


FIGURE 3. I_{CC} (All Outputs Off)

8

test circuits and switching time waveforms (con't)



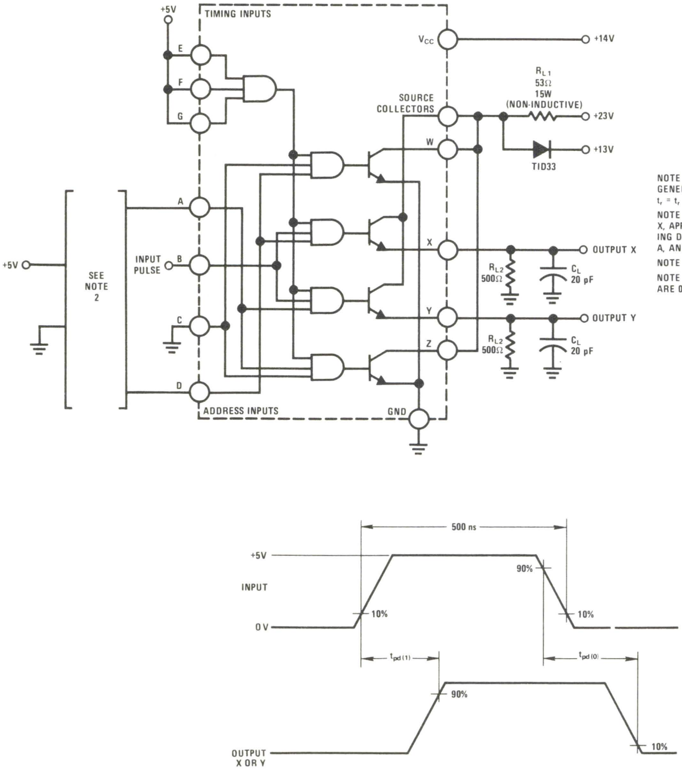
NOTE 1: GND A AND B, APPLY +3.5V TO C AND D, AND MEASURE I_{CC} (OUTPUT W IS ON).

NOTE 2: GND B AND D, APPLY +3.5V TO A AND C, AND MEASURE I_{CC} (OUTPUT Z IS ON).

NOTE 3: GND A AND C, APPLY +3.5V TO B AND D, AND MEASURE I_{CC} (OUTPUT X IS ON).

NOTE 4: GND C AND D, APPLY +3.5V TO A AND B, AND MEASURE I_{CC} (OUTPUT Y IS ON).

FIGURE 4. I_{CC} (One Output On)



NOTE 1: THE INPUT WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS: $t_r = t_f = 10$ ns, DUTY CYCLE $\leq 1\%$, AND $Z_{OUT} \approx 50\Omega$.

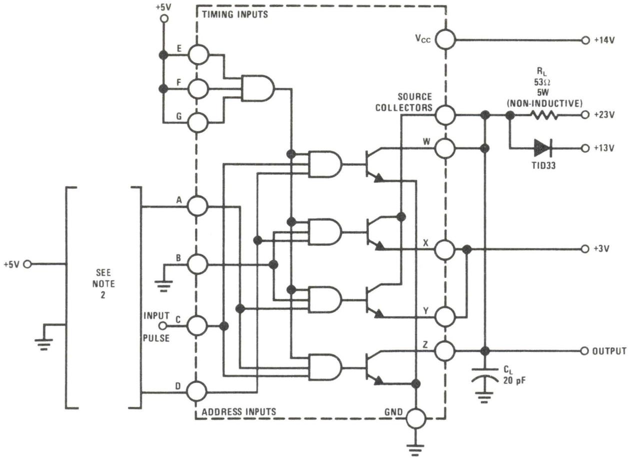
NOTE 2: WHEN MEASURING DELAY TIMES AT OUTPUT X, APPLY +5V TO INPUT D, AND GND A. WHEN MEASURING DELAY TIMES AT OUTPUT Y, APPLY +5V TO INPUT A, AND GND D.

NOTE 3: C_L INCLUDES PROBE AND JIG CAPACITANCE.

NOTE 4: UNLESS OTHERWISE NOTED ALL RESISTORS ARE 0.5W.

FIGURE 5. Source-Output Switching Times

test circuits and switching time waveforms (con't)



NOTE 1: THE INPUT WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS: $t_r = t_f = 10$ ns, DUTY CYCLE $\leq 1\%$, $Z_{OUT} \approx 50\Omega$.

NOTE 2: WHEN MEASURING DELAY TIMES AT OUTPUT W, APPLY +5V TO INPUT D, AND GND A. WHEN MEASURING DELAY TIMES AT OUTPUT Z, APPLY +5V TO INPUT A, AND GND D.

NOTE 3: C_L INCLUDES PROBE AND JIG CAPACITANCE.

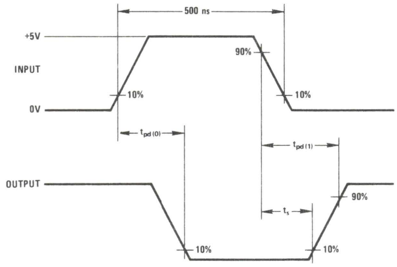


FIGURE 6. Sink-Output Switching Times

Interface Circuits

LM55325/LM75325 memory drivers

general description

The LM55325 and LM75325 are monolithic memory drivers which feature high current outputs as well as internal decoding of logic inputs. These circuits are designed for use with magnetic memories.

The circuit contains two 600 mA sink-switch pairs and two 600 mA source-switch pairs. Inputs A and B determine source selection while the source strobe (S_1) allows the selected source turn on. In the same manner, inputs C and D determine sink selection while the sink strobe (S_2) allows the selected sink turn on.

Sink-output collectors feature an internal pull-up resistor in parallel with a clamping diode connected to V_{CC2}. This protects the outputs from voltage surges associated with switching inductive loads.

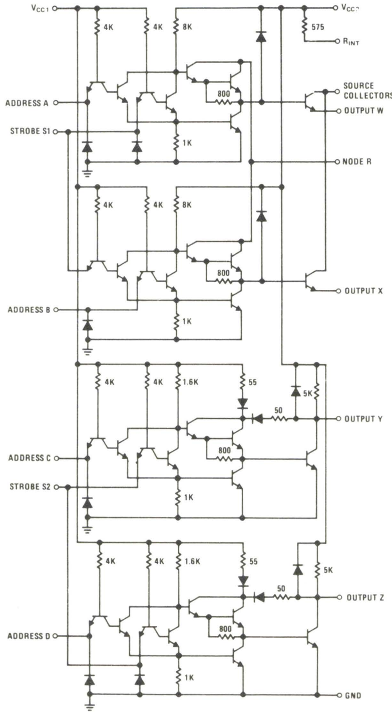
The source stage features Node R which allows extreme flexibility in source current selection by controlling the amount of base drive to each source transistor. This method of setting the base drive brings the power associated with the resistor outside the package thereby allowing the circuit to operate at higher source currents for a given junction temperature. If this method of source current setting is not desired, then Nodes R and R_{INT} can be shorted externally activating an internal resistor connected from V_{CC2} to Node R. This provides adequate base drive for source currents up to 375 mA with V_{CC2} = 15V or 600 mA with V_{CC2} = 24V.

The LM55325 operates over the full military temperature range of -55°C to +125°C, while the LM75325 operates from 0°C to +70°C.

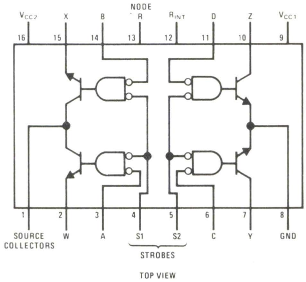
features

- 600 mA output capability
- 24V output capability
- Dual sink and dual source outputs
- Fast switching times
- Source base drive externally adjustable
- Input clamping diodes
- DTL/TTL compatible

schematic and connection diagrams



Dual-In-Line Package



Order Number LM55325J or LM75325J
See Package 17

Order Number LM75325N
See Package 23

truth table

ADDRESS INPUTS				STROBE INPUTS		OUTPUTS			
SOURCE		SINK		SOURCE	SINK	SOURCE		SINK	
A	B	C	D	S1	S2	W	X	Y	Z
L	H	X	X	L	H	ON	OFF	OFF	OFF
H	L	X	X	L	H	OFF	ON	OFF	OFF
X	X	L	H	H	L	OFF	OFF	ON	OFF
X	X	H	L	H	L	OFF	OFF	OFF	ON
X	X	X	X	H	H	OFF	OFF	OFF	OFF
H	H	H	H	X	X	OFF	OFF	OFF	OFF

H = high level, L = low level, X = irrelevant
NOTE: Not more than one output is to be on at any one time.

absolute maximum ratings

Supply Voltage V_{CC1} (Note 1)		7V
Supply Voltage V_{CC2} (Note 1)		25V
Input Voltage (Any Address or Strobe Input)		5.5V
Continuous Total Dissipation at (or Below) +70°C Free-Air Temperature (Note 2)		800 mW
Operating Temperature Range	LM55325	−55°C to +125°C
	LM75325	0°C to +70°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

dc electrical characteristics

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55325			LM75325			
		MIN	TYP*	MAX	MIN	TYP*	MAX	
High Level Input Voltage (V_{IH})	Figure 1 and 2	2			2			V
Low Level Input Voltage (V_{IL})	Figure 3 and 4			0.8			0.8	V
Input Clamp Voltage (V_I)	V_{CC1} = 4.5V, V_{CC2} = 24V, I_{IN} = −12 mA, T_A = 25°C, Figure 5		−1.3	−1.7		−1.3	−1.7	V
Source Collectors Terminal Off State Current (I_{OFF})	V_{CC1} = 4.5V, V_{CC2} = 24V, Full Range, Figure 1			500			200	μA
Source Collectors Terminal Off State Current (I_{OFF})	V_{CC1} = 4.5V, V_{CC2} = 24V, T_A = 25°C, Figure 1		3	150		3	200	μA
High Level Sink Output Voltage (V_{OH})	V_{CC1} = 4.5V, V_{CC2} = 24V, I_{OUT} = 0V, Figure 2	19	23		19	23		V
Saturation Voltage Source Outputs** (V_{SAT})	V_{CC1} = 4.5V, V_{CC2} = 15V, R_L = 24Ω, I_{SOURCE} ≈ −600 mA, Full Range, (Note 3) Figure 3			0.9			0.9	V
Saturation Voltage Source Outputs** (V_{SAT})	V_{CC1} = 4.5V, V_{CC2} = 15V, R_L = 24Ω, I_{SOURCE} ≈ −600 mA, T_A = 25°C, (Note 3) Figure 3		0.43	0.7		0.43	0.75	V
Saturation Voltage Sink Outputs** (V_{SAT})	V_{CC1} = 4.5V, V_{CC2} = 15V, R_L = 24Ω, I_{SINK} ≈ 600 mA, Full Range, (Note 3) Figure 4			0.9			0.9	V
Saturation Voltage Sink Outputs** (V_{SAT})	V_{CC1} = 4.5V, V_{CC2} = 15V, R_L = 24Ω, I_{SINK} ≈ 600 mA, T_A = 25°C, (Note 3) Figure 4		0.43	0.7		0.43	0.75	V
Input Current at Maximum Input Voltage Address Inputs (I_I)	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 5.5V, Figure 5			1			1	mA
Input Current at Maximum Input Voltage Strobe Inputs (I_I)	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 5.5V, Figure 5			2			2	mA
High Level Input Current Address Inputs (I_{IH})	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 2.4V, Figure 5		3	40		3	40	μA
High Level Input Current Strobe Inputs (I_{IH})	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 2.4V, Figure 5		6	80		6	80	μA
Low Level Input Current Address Inputs (I_{IL})	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 0.4V, Figure 5		−1	−1.6		−1	−1.6	mA
Low Level Input Current Strobe Inputs (I_{IL})	V_{CC1} = 5.5V, V_{CC2} = 24V, V_I = 0.4V, Figure 5		−2	−3.2		−2	−3.2	mA
Supply Current, All Sources and Sinks Off From V_{CC1} ($I_{CC\,OFF}$)	V_{CC1} = 5.5V, V_{CC2} = 24V, T_A = 25°C, Figure 6		14	22		14	22	mA
Supply Current, All Sources and Sinks Off From V_{CC2} ($I_{CC\,OFF}$)	V_{CC1} = 5.5V, V_{CC2} = 24V, T_A = 25°C, Figure 6		7.5	20		7.5	20	mA
Supply Current From V_{CC1}, Either Sink On (I_{CC1})	V_{CC1} = 5.5V, V_{CC2} = 24V, I_{SINK} = 50 mA, T_A = 25°C, Figure 7		55	70		55	70	mA
Supply Current From V_{CC2}, Either Source On (I_{CC2})	V_{CC1} = 5.5V, V_{CC} = 24V, I_{SOURCE} = −50 mA, T_A = 25°C, Figure 8		32	50		32	50	mA

Note 1: Voltage values are with respect to network ground terminal.

Note 2: For operation of LM55325 above +70°C free-air temperature, refer to Dissipation Derating Curve (Figure 12).

Note 3: These parameters must be measured using pulse techniques. t_W = 200μs, duty cycle ≤ 2%.

*All typical values are at T_A = 25°C.

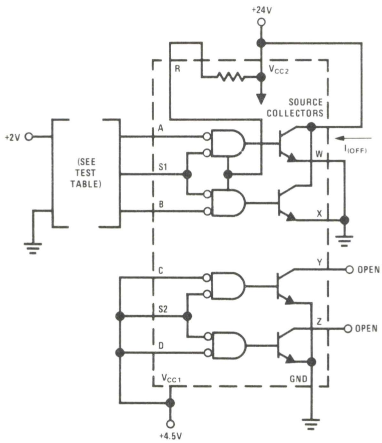
**Not more than one output is to be on at any one time.

8

ac switching characteristics ($V_{CC1} = 5V$, $T_A = 25°C$)

PARAMETER	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
Propagation Delay Time, Low to High Level Output to Source Collectors (t_{PLH})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		25	50	ns
Propagation Delay Time, High to Low Level Output to Source Collectors (t_{PHL})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		25	50	ns
Transition Time, Low to High Level Output to Source Outputs (t_{TLH})	$V_{CC2} = 20V$, $R_L = 1\ k\Omega$, $C_L = 25\ pF$, Figure 10		55		ns
Transition Time, High to Low Level Output to Source Outputs (t_{THL})	$V_{CC2} = 20V$, $R_L = 1\ k\Omega$, $C_L = 25\ pF$, Figure 10		7		ns
Propagation Delay Time, Low to High Level Output to Sink Outputs (t_{PLH})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		20	45	ns
Propagation Delay Time, High to Low Level Output to Sink Outputs (t_{PHL})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		20	45	ns
Transition Time, Low to High Level Output to Sink Outputs (t_{TLH})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		7	15	ns
Transition Time, High to Low Level Output to Sink Outputs (t_{THL})	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		9	20	ns
Storage Time, Sink Outputs (t_S)	$V_{CC2} = 15V$, $R_L = 24\Omega$, $C_L = 25\ pF$, Figure 9		15	30	ns

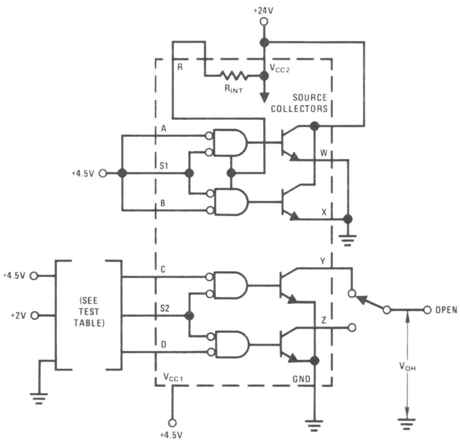
dc test circuits



TEST TABLE

A	B	S1
GND	GND	2V
2V	2V	GND

FIGURE 1. I_{OFF}

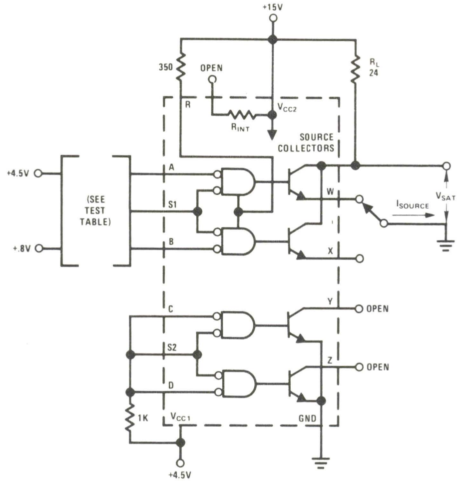


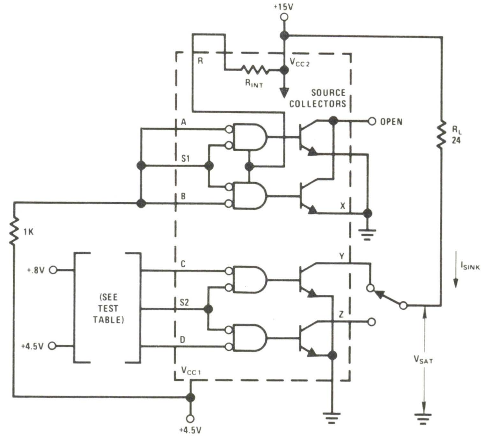
TEST TABLE

C	D	S2	Y	Z
2V	4.5V	GND	V_{OH}	OPEN
GND	4.5V	2V	V_{OH}	OPEN
4.5V	2V	GND	OPEN	V_{OH}
4.5V	GND	2V	OPEN	V_{OH}

FIGURE 2. V_{IH} and V_{OH}

dc test circuits(con't)





NOTE 1: FIGURE 3 AND 4 PARAMETERS MUST BE MEASURED USING PULSE TECHNIQUES. $t_W = 200\mu s$, DUTY CYCLE $\leq$ 2%.

TEST TABLE

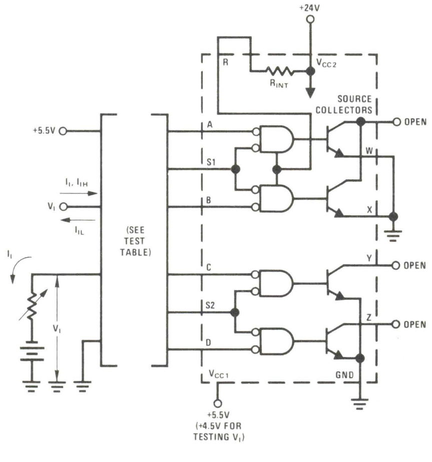
A	B	S1	W	X
0.8V	4.5V	0.8V	GND	OPEN
4.5V	0.8V	0.8V	OPEN	GND

FIGURE 3. V_{IL} and Source V_{SAT}

TEST TABLE

C	D	S2	Y	Z
0.8V	4.5V	0.8V	R_L	OPEN
4.5V	0.8V	0.8V	OPEN	R_L

FIGURE 4. V_{IL} and Sink V_{SAT}



TEST TABLES

I_I, I_{IH}

APPLY V_I = 5.5V MEASURE I_I / APPLY V_I = 2.4V MEASURE I_{IH}	GROUND	APPLY 5.5V
A	S1	B, C, S2, D
S1	A, B	C, S2, D
B	S1	A, C, S2, D
C	S2	A, S1, B, D
S2	C, D	A, S1, B
D	S2	A, S1, B, C

V_I, I_{IL}

APPLY V_I = 0.4V, MEASURE I_{IL} / APPLY I_I = −10 mA, MEASURE V_I	APPLY 5.5V
A	S1, B, C, S2, D
S1	A, B, C, S2, D
B	A, S1, C, S2, D
C	A, S1, B, S2, D
S2	A, S1, B, C, D
D	A, S1, B, C, S2

FIGURE 5. V_I, I_I, I_{IH}, and I_{IL}

dc test circuits(con't)

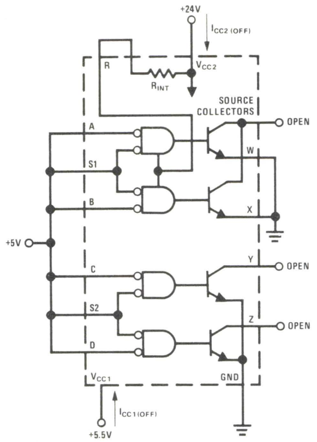
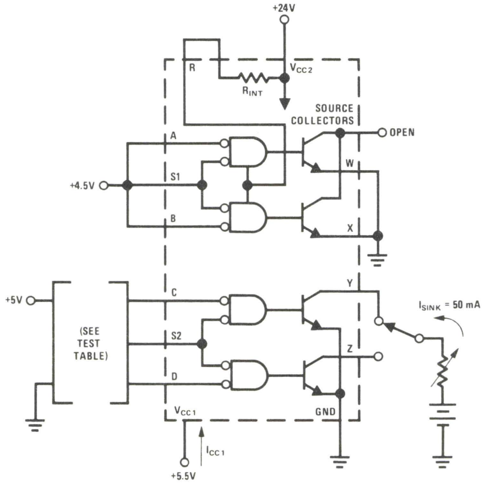


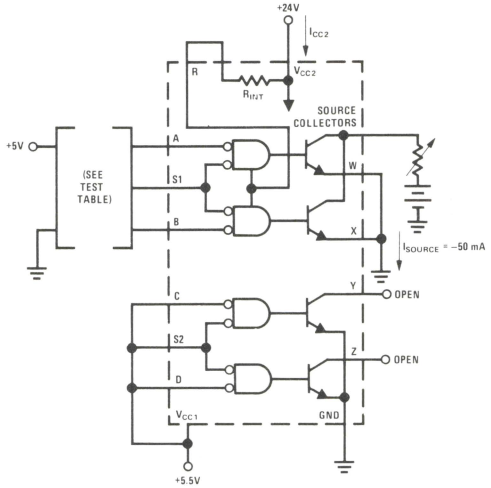
FIGURE 6. $I_{CC1(OFF)}$ and $I_{CC2(OFF)}$



TEST TABLE

C	D	S2	Y	Z
GND	5V	GND	$I_{(SINK)}$	OPEN
5V	GND	GND	OPEN	$I_{(SINK)}$

FIGURE 7. I_{CC1}, Either Sink On

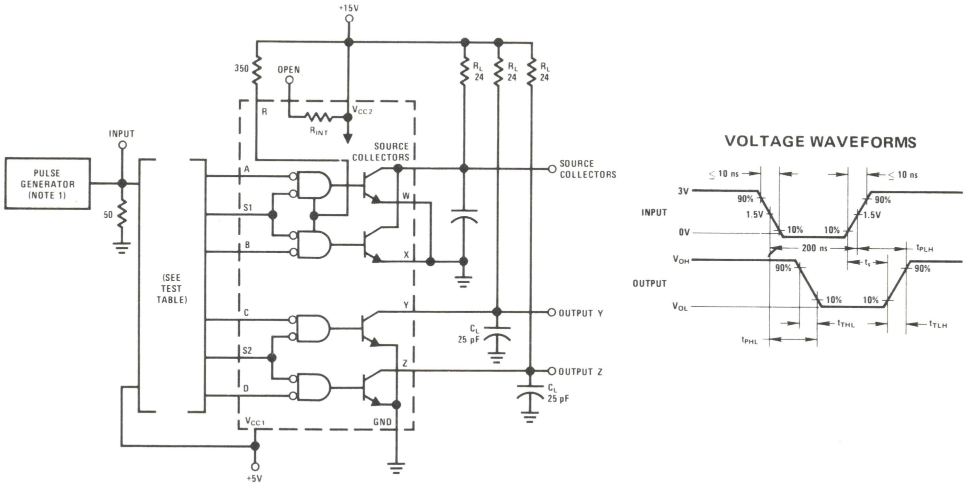


TEST TABLE

A	B	S1
GND	5V	GND
5V	GND	GND

FIGURE 8. I_{CC2}, Either Source On

dc test circuits(con't)



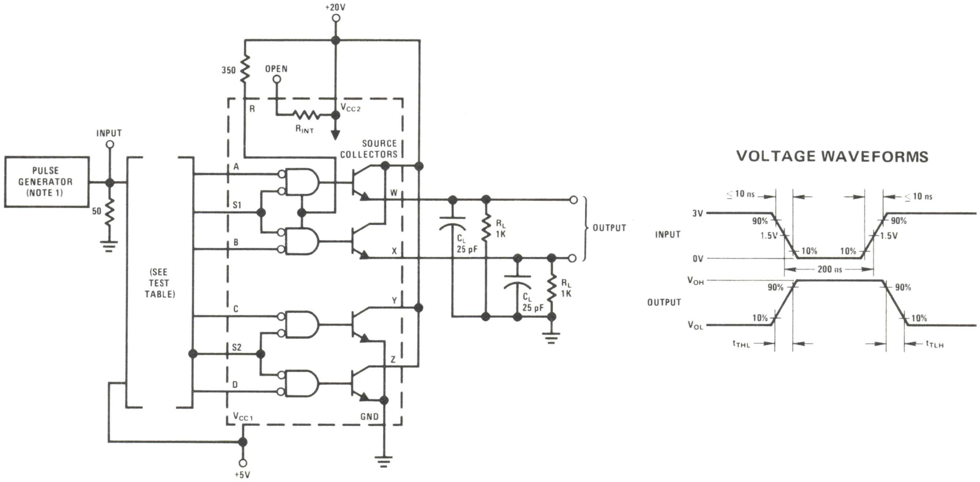
NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: Z_{OUT} = 50Ω, DUTY CYCLE ≤ 1%.

NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.

TEST TABLE

PARAMETER	OUTPUT UNDER TEST	INPUT	CONNECT TO 5V
t_{PLH} and t_{PHL}	Source collectors	A and S1	B, C, D and S2
		B and S1	A, C, D and S2
t_{PLH}, t_{PHL}, t_{TLH}, t_{THL}, and t_s	Sink output Y	C and S2	A, B, D and S1
	Sink output Z	D and S2	A, B, C and S1

FIGURE 9. Switching Times



NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: Z_{OUT} = 50Ω, DUTY CYCLE ≤ 1%.

NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.

TEST TABLE

PARAMETER	OUTPUT UNDER TEST	INPUT	CONNECT TO 5V
t_{TLH} and t_{THL}	Source output W	A and S1	B, C, D, and S2
	Source output X	B and S1	A, C, D, and S2

FIGURE 10. Transition Times of Source Outputs

applications

External Resistor Calculation

A typical magnetic-memory word drive requirement is shown in Figure 11. A source-output transistor of one LM75325 delivers load current (I_L). The sink-output transistor of another LM75325 sinks this current.

The value of the external pull-up resistor (R_{ext}) for a particular memory application may be determined using the following equation:

$$R_{ext} = \frac{16\,[V_{CC2(min)} - V_S - 2.2]}{I_L - 1.6\,[V_{CC2(min)} - V_S - 2.9]} \qquad (1)$$

where: R_{ext} is in kΩ,

$V_{CC2(min)}$ is the lowest expected value of V_{CC2} in volts, V_S is the source output voltage in volts with respect to ground, I_L is in mA.

The power dissipated in resistor R_{ext} during the load current pulse duration is calculated using Equation 2.

$$P_{Rext} \approx \frac{I_L}{16}\,[V_{CC2(min)} - V_S - 2] \qquad (2)$$

where: P_{Rext} is in mW.

After solving for R_{ext}, the magnitude of the source collector current (I_{CS}) is determined from Equation 3.

$$I_{CS} \approx 0.94\,I_L \qquad (3)$$

where: I_{CS} is in mA.

As an example, let $V_{CC2(min)} = 20V$ and $V_L = 3V$ while I_L of 500 mA flows. Using Equation 1:

$$R_{ext} = \frac{16\,(20 - 3 - 2.2)}{500 - 1.6\,(20 - 3 - 2.9)} = 0.5\text{ k}\Omega$$

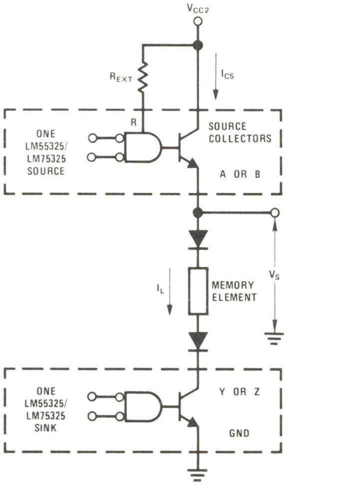
and from Equation 2:

$$P_{Rext} \approx \frac{500}{16}\,[20 - 3 - 2] \approx 470\text{ mW}$$

The amount of the memory system current source (I_{CS}) from Equation 3 is:

$$I_{CS} \approx 0.94\,(500) \approx 470\text{ mA}$$

In this example the regulated source-output transistor base current through the external pull-up resistor (R_{ext}) and the source gate is approximately 30 mA. This current and I_{CS} comprise I_L.



NOTE 1: FOR CLARITY, PARTIAL LOGIC DIAGRAMS OF TWO LM55325'S ARE SHOWN.
NOTE 2: SOURCE AND SINK SHOWN ARE IN DIFFERENT PACKAGES.

FIGURE 11. Typical Application Data

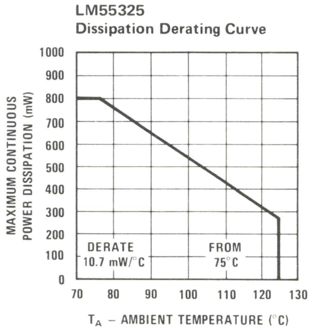


FIGURE 12. Thermal Information

Interface Circuits

LM75450, LM350 dual peripheral driver

general description

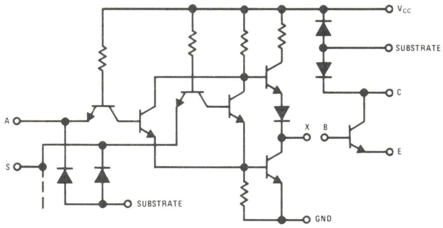
The LM75450 and LM350 are general purpose dual peripheral drivers. The design employs two standard TTL gates (NOR in LM350, NAND in LM75450) and two totally uncommitted, high-voltage, high-current NPN transistors. These transistors are capable of sinking 300 mA and will withstand 30V in the OFF state. Inputs are fully DTL/TTL compatible. The LM75450 meets or exceeds the specifications for both the SN75450 and the SN75450A and is a pin-for-pin replacement.

features

- High speed
- High sink current 300 mA
- Separate gates and transistors
- Both transistors can sink 300 mA simultaneously
- Transistors withstand 30V collector to emitter in the OFF state
- Input clamp diodes

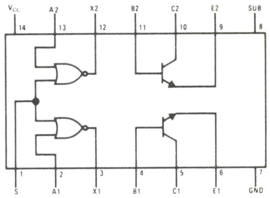
schematic and connection diagrams

LM350



Note: 1/2 of unit shown.

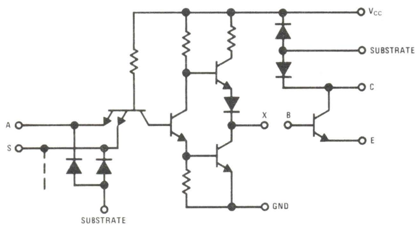
LM350



Positive Logic: $\overline{A+S} = X$

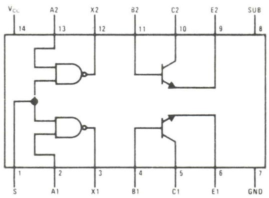
Order Number LM350N
See Package 22

LM75450



Note: 1/2 of unit shown.

LM75450



Positive Logic: $\overline{A \cdot S} = X$

Order Number LM75450N
See Package 22

absolute maximum ratings (Note 1)

Supply Voltage V_{CC}	7V
Input Voltage	5.5V
V_{CC} -to-Substrate Voltage	35V
Collector-to-Substrate Voltage	35V
Collector-Base Voltage	35V
Collector-Emitter Voltage (Note 2)	30V
Emitter-Base Voltage	5V
Continuous Collector Current	300 mA
Continuous Total Power Dissipation (Note 3)	800 mW
Operating Free-Air Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C

electrical characteristics

The following apply for $0°C \le T_A \le 70°C$, V_{CC} = 5V ±5%, for LM75450 and LM350 unless otherwise specified.

TTL GATES

PARAMETER	COMMENTS	LOGIC INPUT	LOGIC OUTPUT	SUPPLY VOLTAGE	MIN	TYP	MAX	UNIT
Logical "1" Input Voltage	Logic Output ≤ 0.4V	V_{IN}	16 mA	4.75V	2			V
Logical "0" Input Voltage	Logic Output ≥ 2.4V	V_{IN}	−400 μA	4.75V			0.8	V
Logical "1" Output Voltage		0.8V	−400 μA	4.75V	2.4			V
Logical "0" Output Voltage		2V	16 mA	4.75V			0.4	V
Logical "1" Input Current	A Input	2.4V		5.25V			40	μA
	S Input	2.4V		5.25V			80	μA
	A Input	5.5V		5.25V			1	mA
	S Input	5.5V		5.25V			2	mA
Logical "0" Input Current	A Input	0.4V		5.25V			−1.6	mA
	S Input	0.4V		5.25V			−3.2	mA
Output Short Circuit Current	Note 4	0V	0V	5.25V	−18		−55	mA
Supply Current:								
Output Low								
LM350	Per Package	5V		5.25V		8	14	mA
LM75450	Per Package	5V		5.25V		6	11	mA
Output High								
LM350	Per Package	0V		5.25V		4	7	mA
LM75450	Per Package	0V		5.25V		2	4	mA
Input Diode Clamp Voltage	T_A = 25°C, V_{SUB} = 0V	−12 mA		5V			−1.5	V

TRANSISTORS

PARAMETER	COMMENTS	BASE	EMITTER	COLLECTOR	MIN	TYP	MAX	UNIT
BV_{CBO}		0V		100 μA	35			V
BV_{CER}	$R_{BE} \le 500\Omega$		0V	100 μA	30			V
BV_{EBO}		0V	100 μA		5			V
V_{BE}		10 mA	0V	100 mA		0.85	1	V
		30 mA	0V	300 mA		1.05	1.2	V
$V_{CE(sat)}$		10 mA	0V	100 mA		0.25	0.4	V
		30 mA	0V	300 mA		0.5	0.7	V
h_{FE}	V_{CE} = 3V, T_A = 0°C, Note 5	I_B	0V	100 mA	20			
	V_{CE} = 3V, T_A = 0°C, Note 5	I_B	0V	300 mA	25			
	V_{CE} = 3V, T_A = 25°C, Note 5	I_B	0V	100 mA	25			
	V_{CE} = 3V, T_A = 25°C, Note 5	I_B	0V	300 mA	30			

The following apply for V_{CC} = 5V, T_A = 25°C

TTL GATES (Note 6)

PARAMETER	TYP	MAX
t_{pd1}	10 ns	22 ns
t_{pd0}	5 ns	15 ns

TRANSISTORS

PARAMETER	TYP	MAX
t_d	6 ns	15 ns
t_r	12 ns	20 ns
t_s	6 ns	15 ns
t_f	8 ns	15 ns

GATES AND TRANSISTORS (Note 7)

PARAMETER	TYP
t_{pd1}	14 ns
t_{pd0}	18 ns
t_r	5 ns
t_f	10 ns

Note 1: All voltage values are with respect to ground terminal. Positive current is defined to be current into referenced pin.

Note 2: With base-emitter resistance < 500Ω.

Note 3: The maximum junction temperature is 150°C. For operating at elevated temperatures the package must be derated based on a thermal resistance of 150°C/W θ_{JA}.

Note 4: Only one output should be shorted at a time.

Note 5: These parameters are to be measured with less than 2% duty cycle.

Note 6: Delays measured with fanout of 10, 15 pF total load capacitance; measured from 1.5V input to 1.5V output.

Note 7: Delays measured with 50Ω load to 10V, 15 pF total load capacitance; measured from 1.5V input to 50% of output.

Interface Circuits

LM75451, LM75452, LM75453 dual peripheral driver

general description

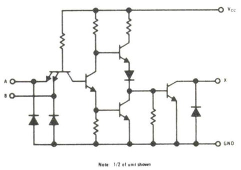
These devices are general purpose dual peripheral drivers, each capable of sinking two independent 300 mA loads to ground. In the off state (or with V_{CC} = 0V) the outputs will withstand 30V. Inputs are fully DTL/TTL compatible. The LM75451 meets or exceeds the specifications for the SN75451 and is a pin-for-pin replacement. The LM75452 and LM75453 meet or exceed the specifications for SN75452 and SN75453, respectively, and are pin-for-pin replacements.

features

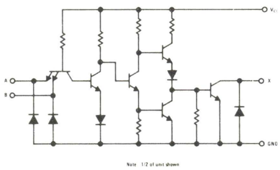
- High speed – 20 ns max (LM75451, LM75453)
  25 ns max (LM75452)
- Both outputs can sink 300 mA simultaneously
- Withstands 30V on output with V_{CC} = 0V for power strobing applications
- Input clamp diodes
- Two separate drivers per package

schematic diagrams

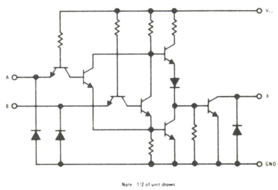
LM75451



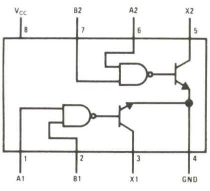
LM75452



LM75453

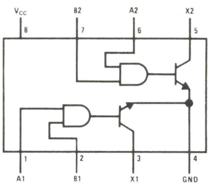


connection diagrams



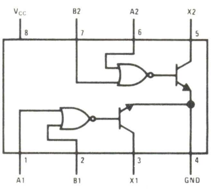
TOP VIEW

Order Number LM75451N
See Package 20



TOP VIEW

Order Number LM75452N
See Package 20



TOP VIEW

Order Number LM75453N
See Package 20

truth tables

Positive logic: AB=X

A	B	OUTPUT X*
0	0	0
1	0	0
0	1	0
1	1	1

*"0" Output ≤ 0.7V
"1" Output ≤ 100 µA

Positive logic: $\overline{AB}$=X

A	B	OUTPUT X*
0	0	1
1	0	1
0	1	1
1	1	0

*"0" Output ≤ 0.7V
"1" Output ≤ 100 µA

Positive logic: A + B = X

A	B	OUTPUT X*
0	0	0
1	0	1
0	1	1
1	1	1

*"0" Output ≤ 0.7V
"1" Output ≤ 100 µA

absolute maximum ratings (Note 1)

Supply Voltage V_{CC}	7V
Input Voltage	5.5V
Output Voltage (Note 2)	30V
Continuous Output Current	300 mA
Continuous Total Power Dissipation (Note 3)	800 mW
Operating Free Air Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics

The following apply for $0°C \le T_A \le 70°C$, V_{CC} = 5V ±5%, unless otherwise specified. (Note 4)

PARAMETER	LOGIC INPUT	OUTPUT	SUPPLY VOLTAGE	COMMENTS	MIN	TYP	MAX	UNIT
Logic "1" Input Voltage	V_{IN}	30V (300 mA)	4.75V	Output ≤ 100 µA (≤0.7V)	2			V
Logic "0" Input Voltage	V_{IN}	300 mA (30V)	4.75V	Output ≤ 0.7V (≤100 µA)			0.8	V
Output Leakage Currents	2V (0.8V)	30V	4.75V				100	µA
		30V	0V				100	µA
Output LOW Voltages	0.8V (2V)	100 mA	4.75V			0.25	0.4	V
	0.8V (2V)	300 mA	4.75V			0.5	0.7	V
Logic "1" Input Currents	2.4V		5.25V				40	µA
	5.5V		5.25V				1	mA
Logic "0" Input Current	0.4V		5.25V			−1	−1.6	mA
Supply Currents:								
Output Low								
LM75451	0V		5.25V	Per Package		48	60	mA
LM75452	5V		5.25V	Per Package		51	65	mA
LM75453	0V		5.25V	Per Package		50	63	mA
Output High								
LM75451	5V		5.25V	Per Package		7	11	mA
LM75452	0V		5.25V	Per Package		9	14	mA
LM75453	5V		5.25V	Per Package		9	14	mA
Input Diode Clamp Voltage	−12 mA		5V	T_A = 25°C			−1.5	V
The following apply for V_{CC} = 5V, T_A = 25°C								
Propagation Delay Times:								
Input to Output HIGH								
LM75451 & LM75453			(Note 5)			11	20	ns
LM75452			(Note 5)			13	25	ns
Input to Output LOW								
LM75451 & LM75453			(Note 5)			16	20	ns
LM75452			(Note 5)			19	25	ns
Output Risetime						4		ns
Output Falltime						10		ns

Note 1: All voltage values are with respect to ground terminal. Positive current is defined to be current into referenced pin.

Note 2: Maximum voltage to be applied to either output in the off state.

Note 3: The maximum junction temperature is 150°C. For operating at elevated temperatures, the package must be derated based on a thermal resistance of 110°C/W θ_{JA}.

Note 4: Test conditions in parentheses pertain to LM75452, other test conditions pertain to LM75451 and LM75453.

Note 5: Delays measured with 50Ω load to 10V, 15 pF total load capacitance; measured from 1.5V input to 50% of output.

Interface Circuits

LM75454 dual peripheral driver

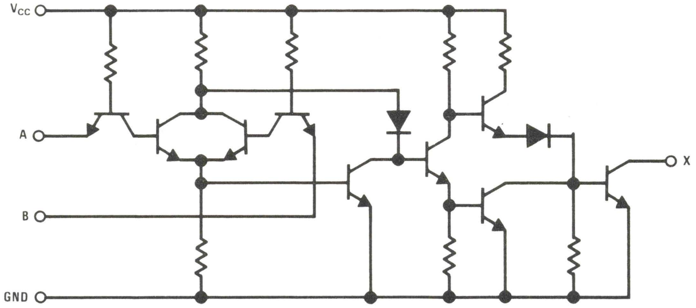
general description

The LM75454 is a dual NOR peripheral line driver with output transistors rated up to 300mA continuous current. Both output transistors can sink this current at the same time, bringing maximum chip power dissipation to 820mW. Switching speeds are compatible with standard TTL and logic levels interface directly with TTL, DTL, and LPTTL logic families. The overall input to output NOR function allows pin for pin replacement with TI's SN75454 positive logic NOR driver.

features

- High speed, 25 ns maximum
- Both outputs can sink 300 mA simultaneously
- Withstands 30V on outputs
- Input clamp diodes
- Maximum package power dissipation at maximum current rating $\leqq$ 820 mW

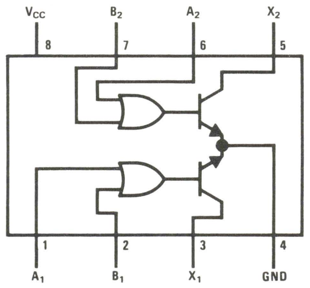
schematic diagram



NOTE: 1/2 SCHEMATIC SHOWN

connection diagram

Dual-In-Line Package



TOP VIEW

Order Number LM75454N
See Package 20

truth table

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

absolute maximum ratings (Note 1)

Supply Voltage, V_{CC}	7V
Input Voltage	5.5V
Output Voltage (Note 4)	30V
Continuous Output Current	300mA
Continuous Total Power Dissipation (Note 2)	820mW
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics The following apply at $0°C \leq T_A \leq +70°C$, V_{CC} = 5V + 5% unless otherwise noted.

PARAMETER	LOGIC INPUT	OUTPUT	SUPPLY VOLTAGE	COMMENTS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	V_{IN}	300mA	4.75V	Output ≤ 0.7V	2.0			V
Logical "0" Input Voltage	V_{IN}	30V	4.75V	Output ≤ 100μA			0.8	V
Logical "1" Input Current	2.4V		5.25V				40	μA
	5.5V		5.25V				1	mA
Logical "0" Input Current	0.4V		5.25V			−1.0	−1.6	mA
Output Low Voltage	2.0V	100mA	4.75V			0.25	0.4	V
	2.0V	300mA	4.75V			0.5	0.7	V
Output Leakage Current	0.8V	30V	4.75V				100	μA
	0.8V	30V	0V				100	μA
Supply Currents:								
Output Low	A_1 = 5V B_1 = 0V		5.25V	Per Package		61	79	mA
Output High	A_1 = B_1 = 0V		5.25V	Per Package		13	17	mA
Input Clamp Diode Voltage	−12mA		5V	T_A = 25°C			−1.5	V
Propagation Delay Times: The following Apply for V_{CC} = 5V, T_A = 25°C								
t_{pd1}, Input "0" to Output "1"			(Note 3)			13	25	ns
t_{pd1}, Input "1" to Output "0"			(Note 3)			19	25	ns
Output Risetime								ns
Output Falltime								ns

Note 1: All voltage values are with respect to ground. Positive current is defined to be current into referenced pin.

Note 2: Maximum junction temperature is 150°C. For operating at elevated temperatures, the package must be derated based on a thermal resistance, θ_{JA}, of 110°C/W.

Note 3: Delay is measured with a 50Ω load to 10V, 15pF load capacitance, measured from 1.5V input to 50% point on output. Unused inputs should be grounded for this test.

Note 4: Maximum voltage to be applied to either output in the off state.

Interface Circuits

DM7820/DM8820 dual line receiver

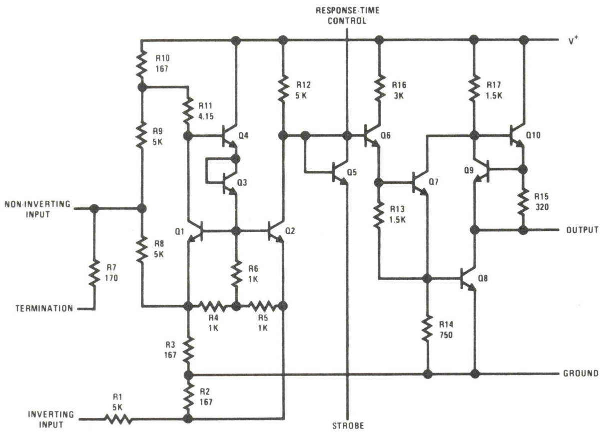
general description

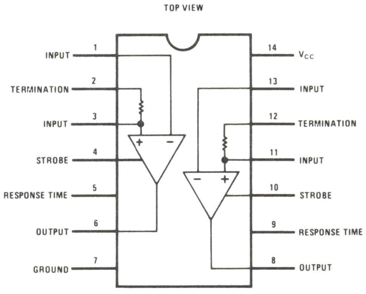
The DM7820, specified from -55°C to 125°C, and the DM8820, specified from 0°C to 75°C, are digital line receivers with two completely independent units fabricated on a single silicon chip. Intended for use with digital systems connected by twisted pair lines, they have a differential input designed to reject large common mode signals while responding to small differential signals. The output is directly compatible with RTL, DTL or TTL integrated circuits. Some important design features include:

- Operation from a single +5V logic supply
- Input voltage range of ±15V
- Each channel can be strobed independently
- High input resistance
- Fanout of two with either DTL or TTL integrated circuits
- Outputs can be wire OR'ed

The response time can be controlled with an external capacitor to eliminate noise spikes, and the output state is determined for open inputs. Termination resistors for the twisted pair line are also included in the circuit. Both the DM7820 and the DM8820 are specified, worst case, over their full operating temperature range, for ±10-percent supply voltage variations and over the entire input voltage range.

schematic and connection diagrams





Note: Pin 7 connected to bottom of package

Order Number DM7820J or DM8820J
See Package 16

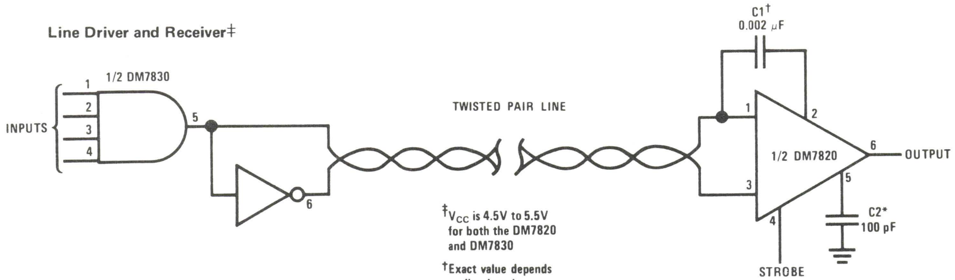
Order Number DM7820W
See Package 27

Order Number DM8820N
See Package 22

Order Number DM8820W
See Package 26

typical application

Line Driver and Receiver‡



‡V_{CC} is 4.5V to 5.5V for both the DM7820 and DM7830

†Exact value depends on line length

*Optional to control response time

absolute maximum ratings

Supply Voltage	8.0V
Input Voltage	±20V
Differential Input Voltage	±20V
Strobe Voltage	8.0V
Output Sink Current	25 mA
Power Dissipation (Note 1)	600 mW
Operating Temperature Range (DM7820)	−55°C to 125°C
Storage Temperature Range (DM8820)	0°C to 70°C
Lead temperature (soldering, 10 sec)	300°C

electrical characteristics (Notes 2 & 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Threshold Voltage	$V_{IN} = 0$ $-15V \leq V_{IN} \leq 15V$	−0.5 −1.0	0 0	0.5 1.0	V V
High Output Level	$I_{OUT} \leq 0.2$ mA	2.5		5.5	V
Low Output Level	$I_{sink} \leq 3.5$ mA	0		0.4	V
Inverting Input Resistance		3.6	5.0		kΩ
Non-inverting Input Resistance		1.8	2.5		kΩ
Line Termination Resistance	$T_A = 25°C$	120	170	250	Ω
Response Time	$C_{delay} = 0$ $C_{delay} = 100$ pF		40 150		ns ns
Strobe Current	$V_{strobe} = 0.4V$ $V_{strobe} = 5.5V$		1.0	1.4 −5.0	mA μA
Power Supply Current	$V_{IN} = 15V$ $V_{IN} = 0$ $V_{IN} = -15V$		3.2 5.8 8.3	6.0 10.2 15.0	mA mA mA
Non-inverting Input Current	$V_{IN} = 15V$ $V_{IN} = 0$ $V_{IN} = -15V$	 −1.6 −9.8	5.0 −1.0 −7.0	7.0	mA mA mA
Inverting Input Current	$V_{IN} = 15V$ $V_{IN} = 0$ $V_{IN} = -15V$	 −4.2	3.0 0 −3.0	4.2 0.5	mA mA mA

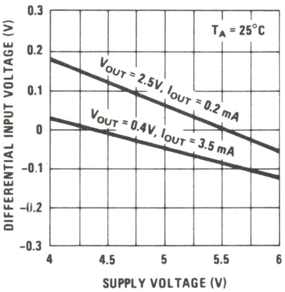
Note 1: For operating at elevated temperatures, the device must be derated based on a thermal resistance of 100°C/W and a maximum junction temperature of 160°C for the DM7820 or 105°C for the DM8820.

Note 2: These specifications apply for $4.5V \leq V_{CC} \leq 5.5V$, $-15V \leq V_{CM} \leq 15V$ and $-55°C \leq T_A \leq 125°C$ for the DM7820 or $0°C \leq T_A \leq 70°C$ for the DM8820 unless otherwise specified: typical values given are for $V_{CC} = 5.0V$, $T_A = 25°C$ and $V_{CM} = 0$ unless stated differently.

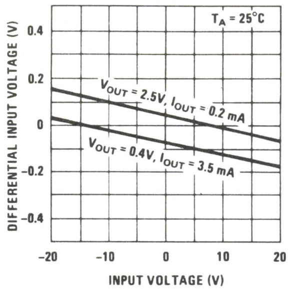
Note 3: The specifications and curves given are for one side only. Therefore, the total package dissipation and supply currents will be double the values given when both receivers are operated under identical conditions.

typical performance characteristics (Note 3)

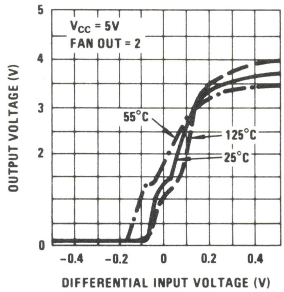
Supply Voltage Sensitivity



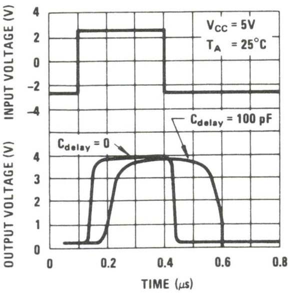
Common Mode Rejection



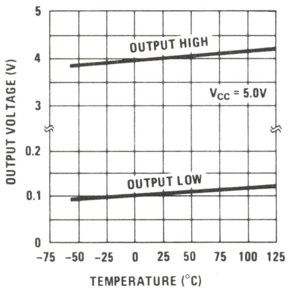
Transfer Function



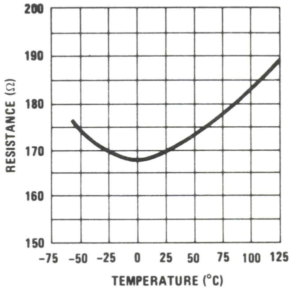
Response Time



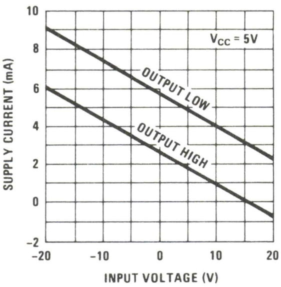
Output Voltage Levels



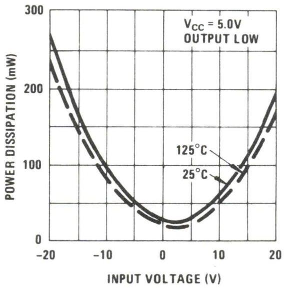
Termination Resistance



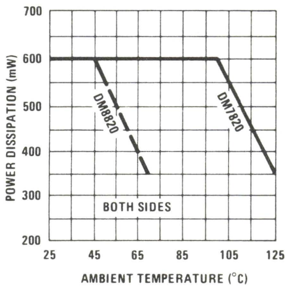
Positive Supply Current



Internal Power Dissipation



Maximum Power Dissipation



Interface Circuits

DM7820A/DM8820A dual line receiver

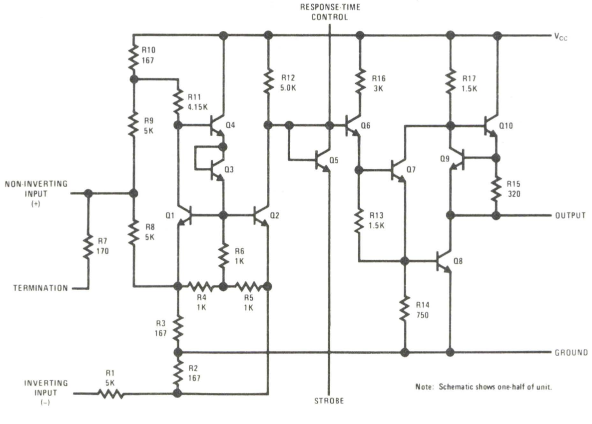
general description

The DM7820A and the DM8820A are improved performance digital line receivers with two completely independent units fabricated on a single silicon chip. Intended for use with digital systems connected by twisted pair lines, they have a differential input designed to reject large common mode signals while responding to small differential signals. The output is directly compatible with RTL, DTL or TTL integrated circuits. Some important design features include:

- Operation from a single +5V logic supply
- Input voltage range of ±15V
- Strobe low forces output to "1" state
- High input resistance
- Fanout of ten with either DTL or TTL integrated circuits
- Outputs can be wire OR'ed
- Series 54/74 compatible

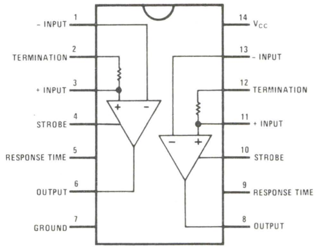
The response time can be controlled with an external capacitor to reject input noise spikes. The output state is a logic "1" for both inputs open. Termination resistors for the twisted pair line are also included in the circuit. Both the DM7820A and the DM8820A are specified, worst case, over their full operating temperature range (−55°C to 125°C and 0°C to 70°C respectively), over the entire input voltage range, for ±10% supply voltage variations.

schematic and connection diagrams



Note: Schematic shows one-half of unit.

Dual-In-Line Package



Note: Pin 7 connected to bottom of cavity package.

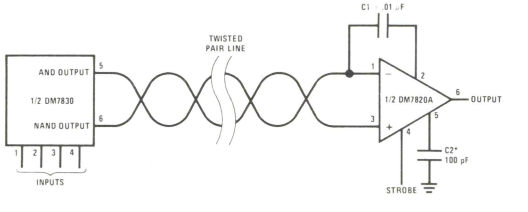
TOP VIEW

Order Number DM7820AD
See Package 1

Order Number DM8820AN
See Package 22

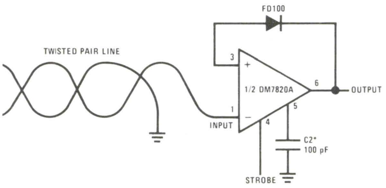
typical applications

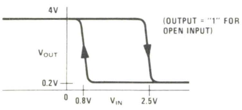
Differential Line Driver and Receiver



*Optional to control response time.

Single Ended (EIA-RS232C) Receiver with Hysteresis





absolute maximum ratings

Supply Voltage	8.0V
Common-Mode Voltage	±20V
Differential Input Voltage	±20V
Strobe Voltage	8.0V
Output Sink Current	50 mA
Power Dissipation (Note 1)	600 mW
Operating Temperature Range	
DM7820A	−55°C to 125°C
DM8820A	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 2, 3 & 4)

PARAMETER	CONDITIONS V_{CM}	CONDITIONS OUTPUT	CONDITIONS OTHER	MIN	TYP	MAX	UNITS
Differential Threshold Voltage	$-3V \leq V_{CM} \leq +3V$	−400 µA	$V_{OUT} \geq 2.5V$		+0.06	+0.5	V
	$-15V \leq V_{CM} \leq +15V$	−400 µA	$V_{OUT} \geq 2.5V$		+0.06	+1.0	V
	$-3V \leq V_{CM} \leq +3V$	+16 mA	$V_{OUT} \leq 0.4V$		−0.08	−0.5	V
	$-15V \leq V_{CM} \leq +15V$	+16 mA	$V_{OUT} \leq 0.4V$		−0.08	−1.0	V
Inverting Input Resistance	$-15V \leq V_{CM} \leq +15V$			3.6	5		kΩ
Non-Inverting Input Resistance	$-15V \leq V_{CM} \leq +15V$			1.8	2.5		kΩ
Line Termination Resistance			$T_A = 25°C$	120	170	250	Ω
Inverting Input Current	+15V				+3.0	+4.2	mA
	0V				0	−0.5	mA
	−15V				−3.0	−4.2	mA
Non-Inverting Input Current	+15V				+5.0	+7.0	mA
	0V				−1.0	−1.6	mA
	−15V				−7.0	−9.8	mA
Power Supply Current	+15V	Logic "0"	$V_{DIFF} = -1V$		+3.9	+6.0	mA
	0V	Logic "0"	$V_{DIFF} = -0.5V$		+6.5	+10.2	mA
	−15V	Logic "0"	$V_{DIFF} = -1V$		+9.2	+14.0	mA
Logical "1" Output Voltage		−400 µA	$V_{DIFF} = +1V$	2.5	4.0	5.5	V
Logical "0" Output Voltage		+16 mA	$V_{DIFF} = -1V$	0	0.22	0.4	V
Logical "1" Strobe Input Voltage		+16 mA	$V_{OUT} \leq 0.4V$, $V_{DIFF} = -3V$	2.1			V
Logical "0" Strobe Input Voltage		−400 µA	$V_{OUT} \geq 2.5V$, $V_{DIFF} = -3V$			0.9	V
Logical "1" Strobe Input Current			$V_{STROBE} = 5.5V$, $V_{DIFF} = +3V$		0.01	5.0	µA
Logical "0" Strobe Input Current			$V_{STROBE} = 0.4V$, $V_{DIFF} = -3V$		−1.0	−1.4	mA
Output Short Circuit Current		0V	$V_{CC} = 5.5V$, $V_{STROBE} = 0V$	−2.8	−4.5	−6.7	mA
Propagation Delays: (see waveforms)							
Differential Input to "0" Output			$V_{CC} = 5V$, $T_A = 25°C$		30	45	ns
Differential Input to "1" Output			$V_{CC} = 5V$, $T_A = 25°C$		24	40	ns
Strobe Input to "0" Output			$V_{CC} = 5V$, $T_A = 25°C$		16	25	ns
Strobe Input to "1" Output			$V_{CC} = 5V$, $T_A = 25°C$		18	30	ns

Note 1: For operating at elevated temperatures, the device must be derated based on a thermal resistance of 100°C/W and a maximum junction temperature of 160°C for the DM7820A, or 150°C/W and 115°C maximum junction temperature for the DM8820A.

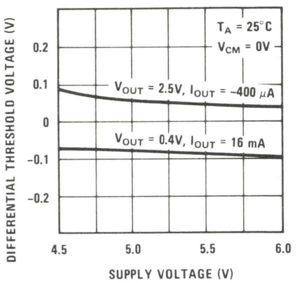
Note 2: These specifications apply for $4.5V \leq V_{CC} \leq 5.5V$, $-15V \leq V_{CM} \leq 15V$ and $-55°C \leq T_A \leq 125°C$ for the DM7820A or $0°C \leq T_A \leq 70°C$ for the DM8820A unless otherwise specified. Typical values given are for $V_{CC} = 5.0V$, $T_A = 25°C$ and $V_{CM} = 0V$ unless stated differently.

Note 3: The specifications and curves given are for one side only. Therefore, the total package dissipation and supply currents will be double the values given when both receivers are operated under identical conditions.

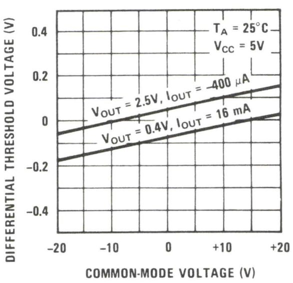
Note 4: Min and max limits apply to absolute values.

typical performance characteristics (Note 3)

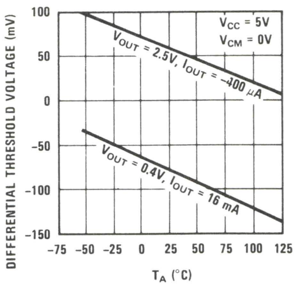
Supply Voltage Sensitivity



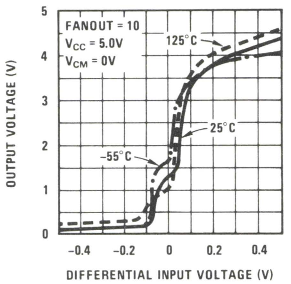
Common-Mode Voltage Sensitivity



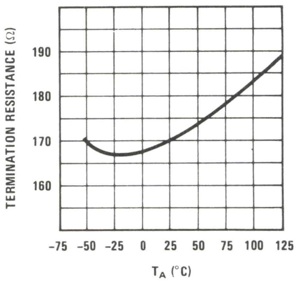
Temperature Sensitivity



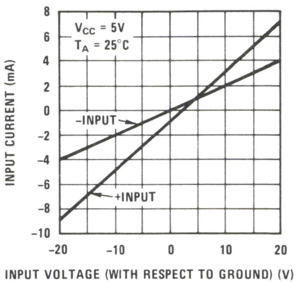
Transfer Function



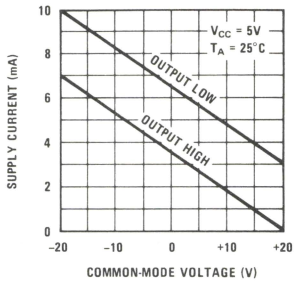
Termination Resistance



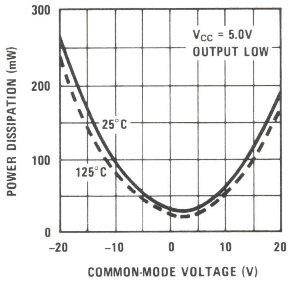
Input Characteristics



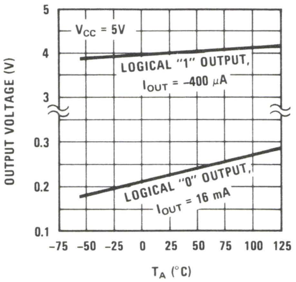
Power Supply Current



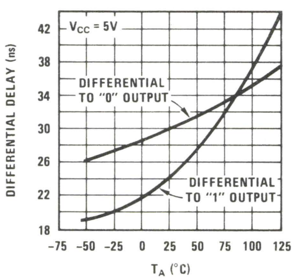
Internal Power Dissipation



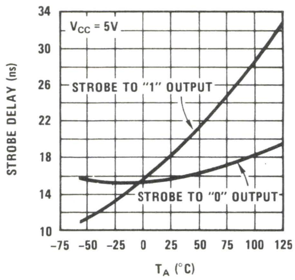
Output Voltage Levels



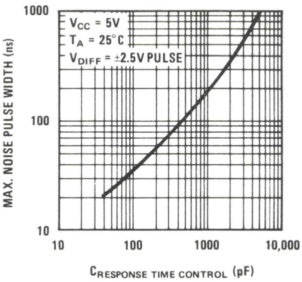
Differential Input Delays



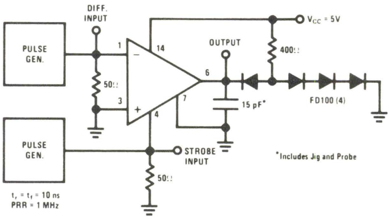
Strobe Delays

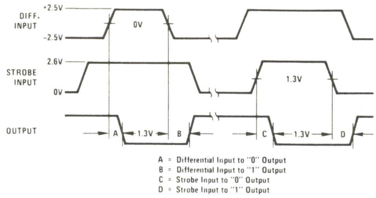


Noise Rejection



ac test circuit and waveforms





Interface Circuits

DM7822/DM8822 dual line receiver

general description

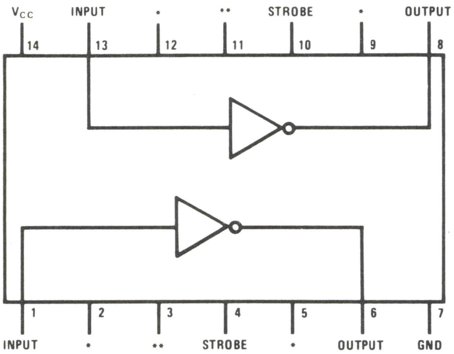
The DM7822/DM8822 is a dual inverting line receiver which meets the requirements of EIA specification RS232 Revision B. The device contains both receivers on a single monolithic silicon chip. The receivers share common power supply and ground connections, otherwise their operation is fully independent.

In addition to meeting the requirements of RS232, the DM7822/DM8822 also has independent strobe inputs which allow the receiver to be placed in the high state independent of the information being received at the input.

The output of the DM7822/DM8822 is completely compatible with five volt DTL and TTL logic families.

The DM7822 is specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The DM8822 is specified for operation over the $0^{\circ}C$ to $+70^{\circ}C$ temperature range.

connection diagram



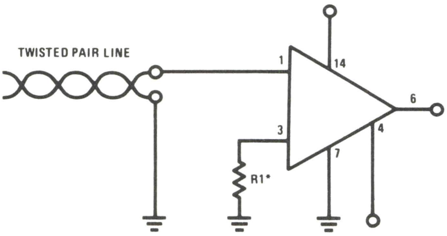
*Make no connection to these pins.

**For operation requiring "Mark Hold" with the input open connect a 470Ω resistors from each of these pins to ground.

Order Number DM7822J or DM8822J
See Package 16

Order Number DM8822N
See Package 22

typical connection



*For Mark Hold R1 = 470Ω, otherwise connect pin 3 to ground.

absolute maximum ratings

Supply Voltage		8.0V
Input Voltage		±30V
Strobe Voltage		8.0V
Output Sink Current		25 mA
Power Dissipation (Note 1)		600 mW
Operating Temperature Range	DM7822	−55°C to +125°C
	DM8822	0°C to 70°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 2)

PARAMETER	PARAGRAPH IN RS-232	CONDITIONS	MIN	TYP	MAX	UNITS
Negative Input Threshold Voltage	4.8 (8)	$V_{OUT} \geq 2.5V$	−2.0			V
Positive Input Threshold Voltage (Note 3)		$V_{OUT} \leq 0.4V$			2.0	V
Input Resistance	4.5 and 4.8 (5)		3.0	5.0	7.0	kΩ
Input Current		$V_{IN} = 25V$	3.57	5	8.33	mA
		$V_{IN} = 0V$		0		mA
		$V_{IN} = -25V$	−8.33	−5	−3.57	mA
Open Circuit Input Voltage	4.5 and 4.8 (4)	$V_{IN} = 0V$		.03	0.5	V
Logical "1" Output Voltage		$I_{OUT} \leq -0.2$ mA	2.5			V
Logical "0" Output Voltage		$I_{OUT} = 3.5$ mA			0.4	V
Strobe Current		$V_{STROBE} = 0.4V$		1.0	1.4	mA
		$V_{STROBE} = 5.5V$		−5.0 μA	−1.0 mA	
Power Supply Current (Both Receivers)		$-25V \leq V_{IN} \leq 25V$			24.0	mA
Response Time, t_1 or t_2		$T_A = 25°C$ $V_{CC} = 5.0V$ Input Ramp Rate ≤ 10 ns		65	125	ns

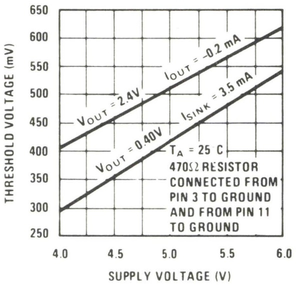
Note 1. For operating at elevated temperatures, the device must be derated in accordance with the "Maximum Power Dissipation" curve.

Note 2. Min/Max limits apply across the guaranteed temperature range of −55°C to +125°C for the DM7822 and 0°C to 70°C for the DM8822 unless otherwise specified. Likewise the limits apply across the guaranteed V_{CC} range of 4.5V to 5.5V for the DM7822 and 4.75V to 5.25V for the DM8822 unless otherwise specified. Typical values are given for $V_{CC} = 5.0V$ and $T_A = 25°C$.

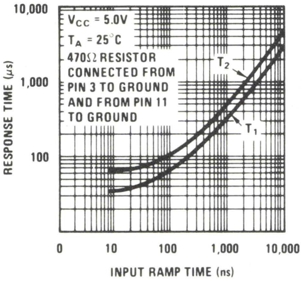
Note 3. Since the EIA RS-232 specification requires the threshold to be between −3V and +3V, the immunity limits shown here guarantee 1 volt additional noise immunity.

typical performance characteristics

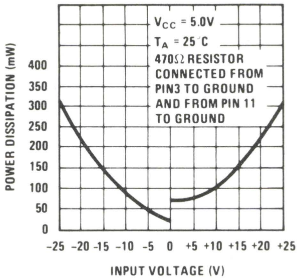
Threshold Voltage vs Supply Voltage



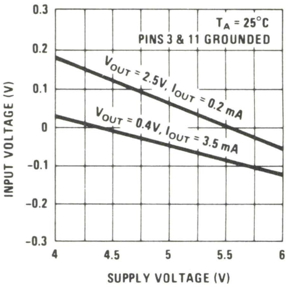
Response Time vs Input Ramp Time



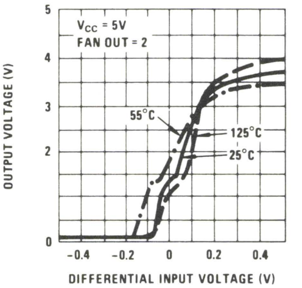
Internal Power Dissipation



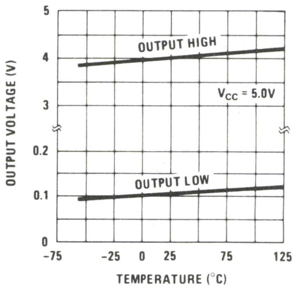
Threshold Voltage vs Supply Voltage



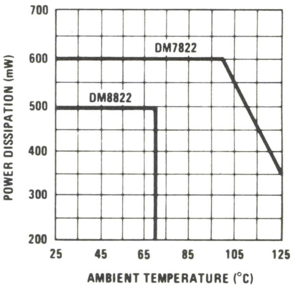
Transfer Function



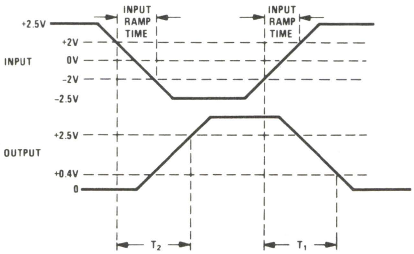
Output Voltage Levels



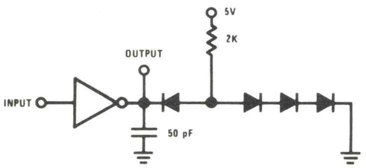
Maximum Power Dissipation



switching time waveforms



ac test circuit



Interface Circuits

DM7830/DM8830 dual differential line driver

general description

The DM7830/DM8830 is a dual differential line driver that also performs the dual four-input NAND or dual four-input AND function.

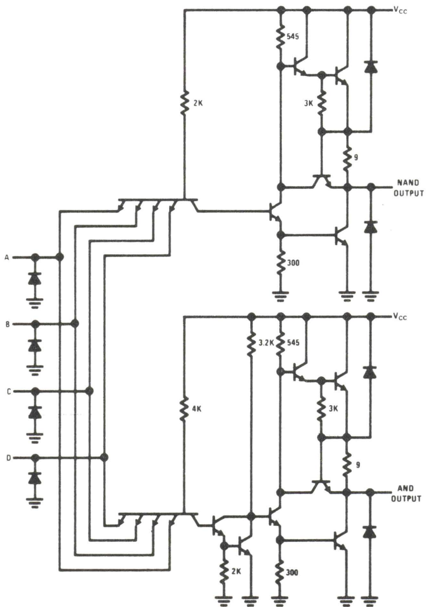
TTL (Transistor-Transistor-Logic) multiple emitter inputs allow this line driver to interface with standard TTL or DTL systems. The differential outputs are balanced and are designed to drive long lengths of coaxial cable, strip line, or twisted pair transmission lines with characteristic impedances of 50Ω to 500Ω. The differential feature of the output eliminates troublesome ground-loop errors normally associated with single-wire transmissions.

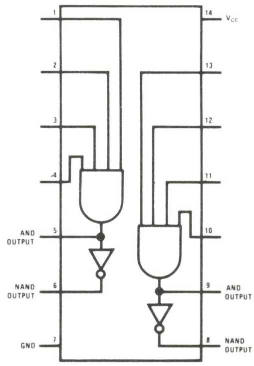
Key Features:

- Single 5 volt power supply
- Diode protected outputs for termination of positive and negative voltage transients
- Diode protected inputs to prevent line ringing
- High Speed
- Short Circuit Protection

The DM7830 is specified for operation over the −55°C to +125°C military temperature range. The DM8830 is specified for operation over the 0°C to +70°C

schematic* and connection diagram





Order Number DM7830J or DM8830J
See Package 16

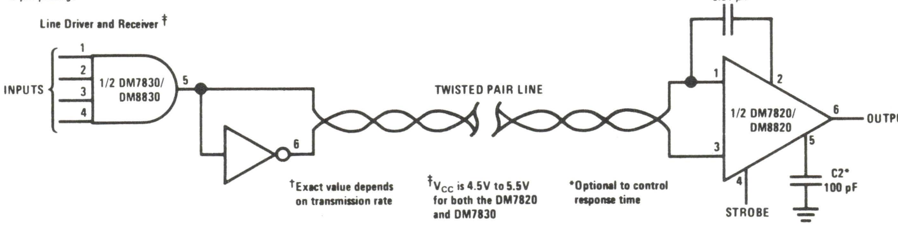
Order Number DM7830W or DM8830W
See Package 27

Order Number DM8830N
See Package 22

typical application

Digital Data Transmission

*2 per package



†Exact value depends on transmission rate

‡V_{CC} is 4.5V to 5.5V for both the DM7820 and DM7830

*Optional to control response time

absolute maximum ratings

V_{CC}		7.0V
Input Voltage		5.5V
Operating Temperature	DM7830	−55°C to +125°C
	DM8830	0°C to 70°C
Storage Temperature		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C
Output Short Circuit Duration (125°C)		1 second

electrical characteristics (Note 1)

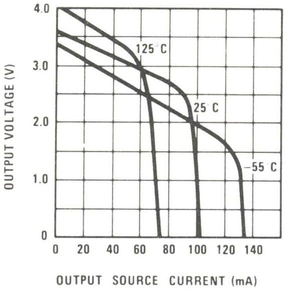
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage		2.0			V
Logical "0" Input Voltage				0.8	V
Logical "1" Output Voltage	V_{IN} = 0.8V I_{OUT} = −0.8 mA	2.4			V
Logical "1"Output Voltage	V_{IN} = 0.8V I_{OUT} = −40 mA	1.8	2.9		V
Logical "0" Output Voltage	V_{IN} = 2.0V I_{OUT} = +32 mA		0.2	0.4	V
Logical "0" Output Voltage	V_{IN} = 2.0V I_{OUT} = +40 mA		0.22	0.5	V
Logical "1" Input Current	V_{IN} = +2.4V			120	μA
Logical "1" Input Current	V_{IN} = 5.5V			2	mA
Logical "0" Input Current	V_{IN} = 0.4V			4.8	mA
Output Short Circuit Current	V_{CC} = 5.0V	Note 2 −40	−100	Note 2 −120	mA
Supply Current	V_{CC} = 5.0V V_{IN} = 5.0V (Each Driver)		11	18	mA
Propagation Delay AND Gate t_{pd1}	T_A = 25°C		8	12	ns
t_{pd0}	V_{CC} = 5.0V		11	18	ns
Propagation Delay NAND Gate t_{pd1}	C_L = 15 pF		8	12	ns
t_{pd0}	See Figure 1 and 1A		5	8	ns
Differential Delay t_1	Load, 100Ω and 5000 pF		12	16	ns
Differential Delay t_2	See Figure 2		12	16	ns

Note 1: Specifications apply for DM7830 −55°C ≤ T_A ≤ +125°C, V_{CC} = +5V ±10%, DM8830 0°C ≤ T_A ≤ 70°C, V_{CC} = +5V ±5% unless otherwise stated. Typical values given are for T_A = 25°C, V_{CC} = 5.0V.

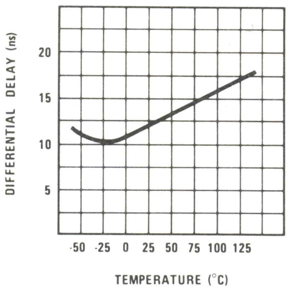
Note 2: Applies for T_A = +125°C only.

typical performance characteristics

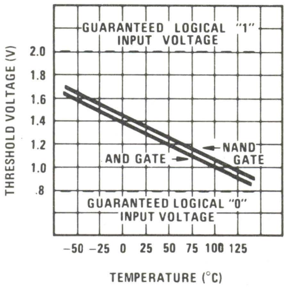
Output High Voltage (Logical "1") Vs Output Current



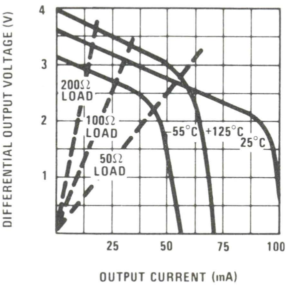
Differential Delay Vs Temperature



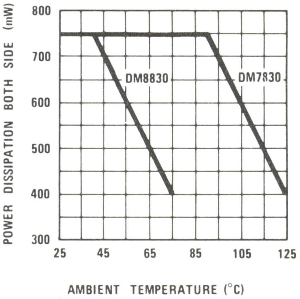
Threshold Voltage Vs Temperature



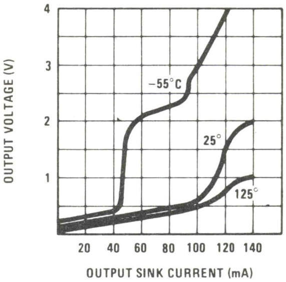
Differential Output Voltage (|V_{AND} − V_{NAND}|) Vs Differential Output Current



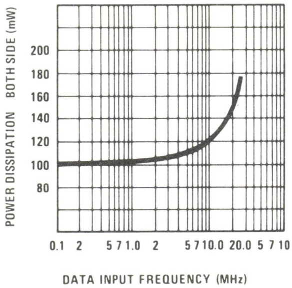
Maximum Power Dissipation



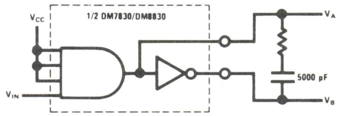
Output Low Voltage (Logical "0") Vs Output Current



Power Dissipation (No Load) Vs Data Input Frequency



ac test circuit



switching time waveforms

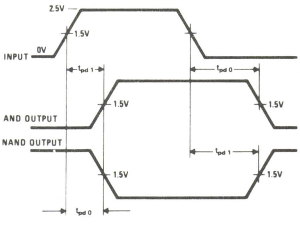


FIGURE 1

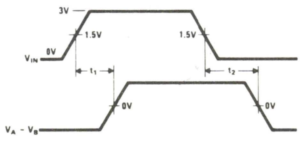


FIGURE 2

Interface Circuits

DM7831/DM8831, DM7832/DM8832 TRI-STATE™ line driver

general description

Through simple logic control, the DM7831/DM8831, DM7832/DM8832 can be used as either a quad single-ended line driver or a dual differential line driver. They are specifically designed for party line (bus-organized) systems. The DM7832/DM8832 does not have the V_{CC} clamp diodes found on the DM7831/DM8831.

The DM7831 & DM7832 are specified for operation over the −55°C to +125°C military temperature range. The DM8831 & DM8832 are specified for operation over the 0°C to +70°C temperature range.

Key features include:

- Series 54/74 compatible
- 17 ns propagation delay
- Very low output impedance—high drive capability
- 40 mA sink and source currents
- Gating control to allow either single-ended or differential operation
- High impedance output state which allows many outputs to be connected to a common bus line.

mode of operation

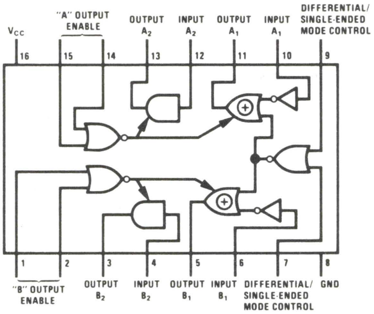
To operate as a quad single-ended line driver apply logical "0"s to the Output Disable pins (to keep the outputs in the normal low impedance mode) and apply logical "0"'s to both Differential/Single-ended Mode Control inputs. All four channels will then operate independently and no signal inversion will occur between inputs and outputs.

To operate as a dual differential line driver apply logical "0"s to the Output Disable pins and apply at least one logical "1" to the Differential/Single-ended Mode Control inputs. The inputs to the A channels should be connected together and the inputs to the B channels should be connected to- In this mode the signals applied to the resulting inputs will pass non-inverted on the A_2 and B_2 outputs and inverted on the A_1 and B_1 outputs.

When operating in a bus-organized system with outputs tied directly to outputs of other

(continued on page 3)

connection and logic diagram



Order Number DM7831J or DM8831J or DM7832J or DM8832J
See Package 17

Order Number DM7831W or DM8831W or DM7832W or DM8832W
See Package 28

Order Number DM8831N or DM8832N
See Package 23

truth-table (Shown for A Channels Only)

"A" OUTPUT DISABLE	DIFFERENTIAL/ SINGLE-ENDED MODE CONTROL	INPUT A_1	OUTPUT A_1	INPUT A_2	OUTPUT A_2
0 0	0 0	Logical "1" or Logical "0"	Same as Input A_1	Logical "1" or Logical "0"	Same as Input A_2
0 0	X 1 1 X	Logical "1" or Logical "0"	Opposite of Input A_1	Logical "1" or Logical "0"	Same as Input A_2
1 X X 1	X X	X	High impedance state	X	High impedance state

X = Don't Care

absolute maximum ratings

Supply Voltage		7V
Input Voltage		5.5V
Output Voltage		5.5V
Storage Temperature Range		-65°C to +150°C
Operating Temperature Range	DM7831, DM7832	-55°C to +125°C
	DM8831, DM8832	0°C to +70°C
Lead Temperature (Soldering, 10 sec.)		300°C
Time that 2 bus-connected devices may be in opposite low impedance states simultaneously		10 ms

electrical characteristics (Note 1)

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	DM7831,DM7832	V_{CC} = 4.5V		2.0			V
	DM8831,DM8832	V_{CC} = 4.75V					
Logical "0" Input Voltage	DM7831,DM7832	V_{CC} = 4.5V				0.8	V
	DM8831,DM8832	V_{CC} = 4.75V					
Logical "1" Output Voltage	DM7831,DM7832	V_{CC} = 4.5V	I_O = -40 mA	1.8	2.3		V
			I_O = -2 mA	2.4	2.7		V
	DM8831,DM8832	V_{CC} = 4.75V	I_O = -40 mA	1.8	2.5		V
			I_O = -5.2 mA	2.4	2.9		V
Logical "0" Output Voltage	DM7831,DM7832		I_O = 40 mA		0.29	0.50	V
			I_O = 32 mA			.40	V
	DM8831,DM8832		I_O = 40 mA		0.29	0.50	V
			I_O = 32 mA			.40	V
Logical "1" Input Current	DM7831,DM7832	V_{CC} = 5.5V	V_{IN} = 5.5V			1	mA
	DM8831,DM8832	V_{CC} = 5.25V	V_{IN} = 2.4V			40	μA
Logical "0" Input Current	DM7831,DM7832	V_{CC} = 5.5V	V_{IN} = 0.4V		-1.0	-1.6	mA
	DM8831,DM8832	V_{CC} = 5.25V					
Output Disable Current	DM7831,DM7832	V_{CC} = 5.5V	V_O = 2.4V or 0.4V	-40		40	μA
	DM8831,DM8832	V_{CC} = 5.25V					
Output Short Circuit Current	DM7831,DM7832	V_{CC} = 5.5V		-40 (Note 2)	-100	-120 (Note 2)	mA
	DM8831,DM8832	V_{CC} 5.25V					
Supply Current	DM7831,DM7832	V_{CC} = 5.5V			65	90	mA
	DM8831,DM8832	V_{CC} = 5.25V					
Input Diode Clamp Voltage		V_{CC} = 5.0V, T_A = 25°C, I_{IN} = -12 mA				-1.5	V
Output Diode Clamp Voltage	DM7831,DM7832	I_{OUT} = -12 mA, V_{CC} = 5.0V, T_A = 25°C				-1.5	V
	DM8831,DM8832	I_{OUT} = +12 mA, V_{CC} = 5.0V, T_A = 25°C				V_{CC}+1.5	V
Propagation Delay to a Logical "0" from Inputs A_1, A_2, B_1, B_2 Differential Single-ended Mode Control to Outputs, t_{pd0}		V_{CC} = 5.0V, T_A = 25°C			13	25	ns
Propagation Delay to a Logical "1" from Inputs A_1, A_2, B_1, B_2 Differential Single-ended Mode Control to Outputs, t_{pd1}		V_{CC} = 5.0V, T_A = 25°C			13	25	ns
Delay from Disable Inputs to High Impedance State (from Logical "1" Level), t_{1H}		V_{CC} = 5.0V, T_A = 25°C			6	12	ns
Delay from Disable Inputs to High Impedance State (from Logical "0" Level), t_{0H}		V_{CC} = 5.0V, T_A = 25°C			14	22	ns
Propagation Delay from Disable Inputs to Logical "1" Level (from High Impedance State), t_{H1}		V_{CC} = 5.0V, T_A = 25°C			14	22	ns
Propagation Delay from Disable Inputs to Logical "0" Level (from High Impedance State), t_{H0}		V_{CC} = 5.0V, T_A = 25°C			18	27	ns

Note 1: Unless otherwise specified min/max limits apply across the -55°C to +125°C temperature range for the DM7831, DM7832 and across the 0°C to 70°C temperature range for the DM8831, DM8832. All typicals are given for V_{CC} = 5.0V and T_A = 25°C.

Note 2: Applies for T_A = 125°C only. Only one output should be shorted at a time.

mode of operation (cont.)

DM7831/DM8831's, DM7832/DM8832's (Figure 1), all devices except one must be placed in the "high impedance" state. This is accomplished by ensuring that a logical "1" is applied to at least one of the Output Disable pins of each device which is to be in the "high impedance" state. A NOR gate was purposely chosen for this function since it is possible with only two DM5442/DM7442, BCD-to-decimal decoders, to decode as many as 100 DM7831/DM8831's, DM7832/DM8832's (Figure 2).

The unique device whose Disable inputs receive two logical "0" levels assumes the normal low impedance output state, providing good capacitive drive capability and waveform integrity especially during the transition from the logical "0" to logical "1" state. The other outputs—in the high impedance state—take only a small amount of leakage current from the low impedance outputs. Since the logical "1" output current from the selected device is 100 times that of a conventional Series 54/74 device (40 mA vs. 400 μA), the output is easily able to supply that leakage current for several hundred other DM7831/DM8831's, DM7832/DM8832's and still have available drive for the bus line (Figure 3).

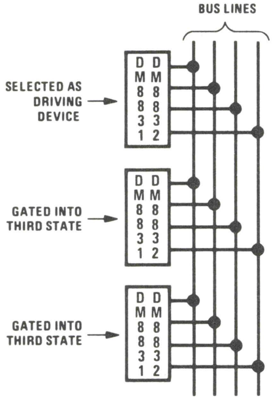


Figure 1

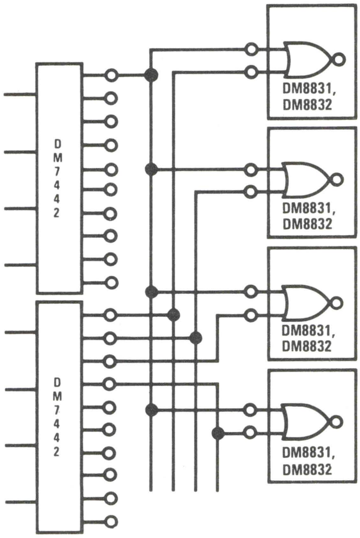


Figure 2

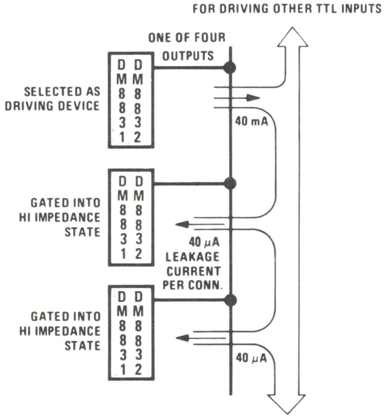
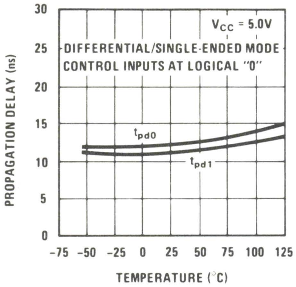


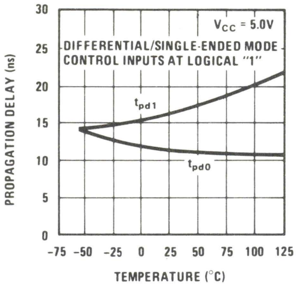
Figure 3

typical performance characteristics

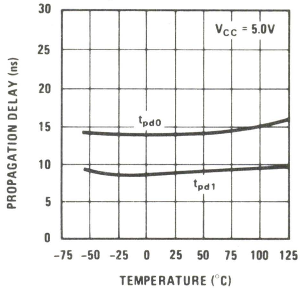
Propagation Delay from Input to Output (Channel 1)



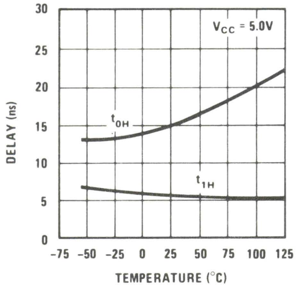
Propagation Delay from Input to Output (Channel 1)



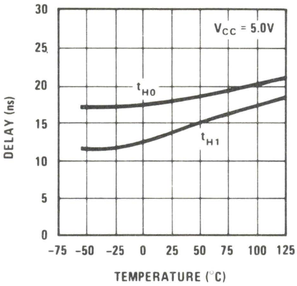
Propagation Delay from Input to Output (Channel 2)



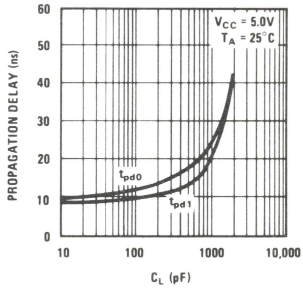
Delay from Disable to High Impedance State



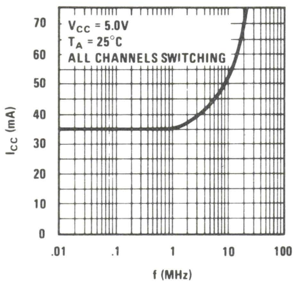
Delay from Disable to Low Impedance State



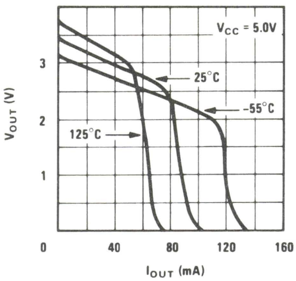
Propagation Delay vs Load Capacitance



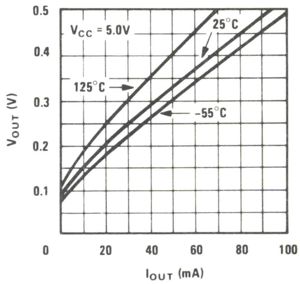
Total Supply Current vs Frequency



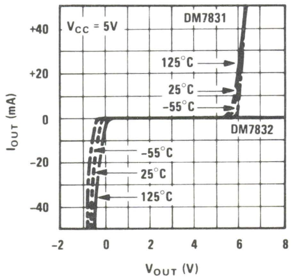
Logical "1" Output Voltage vs Source Current



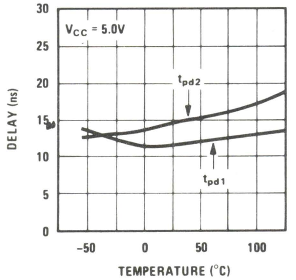
Logical "0" Output Voltage vs Sink Current

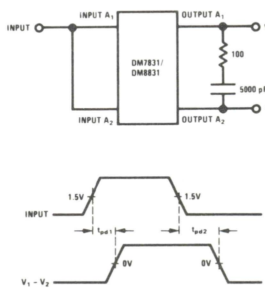


I_{OUT} vs V_{OUT} High Impedance Output State



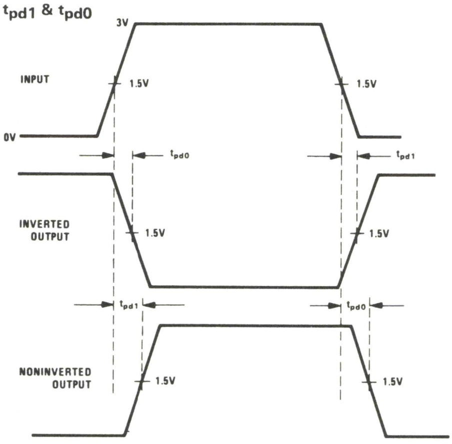
Propagation Delay in Differential Mode





switching time waveforms

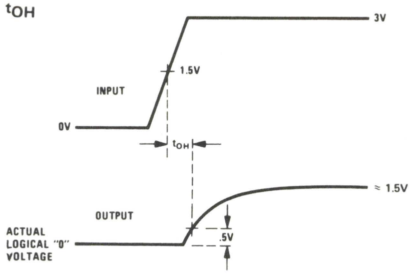
t_{pd1} & t_{pd0}



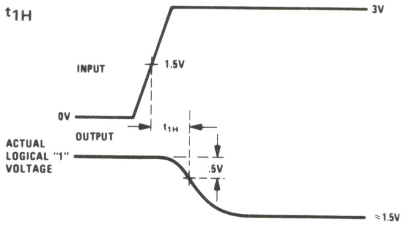
Input characteristic

Amplitude = 3V
frequency = 1 MHz, 50% duty cycle.
$t_r = t_f \leq 10$ nsec (10% to 90%)

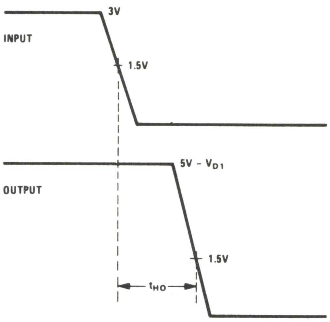
t_{OH}



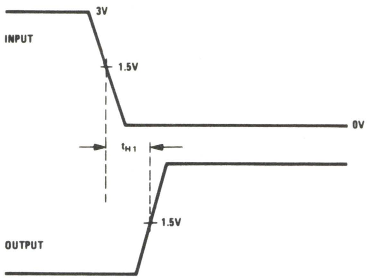
t_{1H}



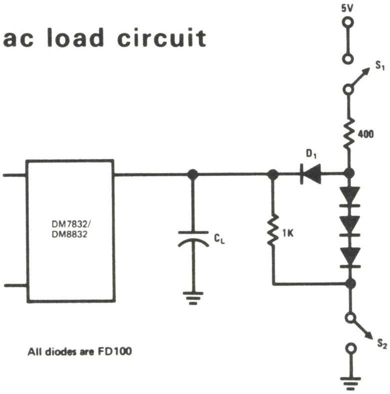
t_{HO}



t_{H1}



ac load circuit



All diodes are FD100

	Switch S_1	Switch S_2	C_L
t_{pd1}	closed	closed	50 pF
t_{pd0}	closed	closed	50 pF
t_{OH}	closed	closed	* 5 pF
t_{1H}	closed	closed	* 5 pF
t_{H0}	closed	open	50 pF
t_{H1}	open	closed	50 pF

*jig capacitance

Interface Circuits

DM7836/DM8836 quad NOR unified bus receiver

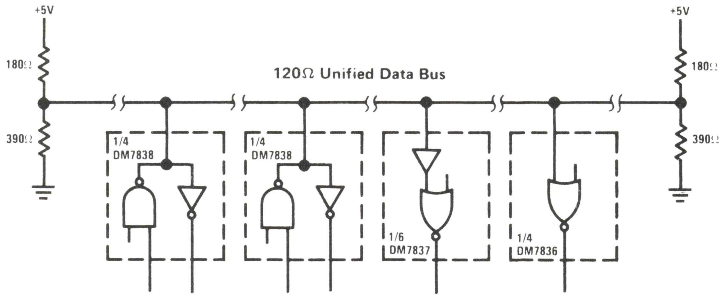
general description

The DM7836/DM8836 are quad 2-input receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The design employs a built-in input hysteresis providing substantial noise immunity. Low input current allows up to 27 driver/receiver pairs to utilize a common bus. This receiver has been specifically configured to replace the SP380 gate pin-for-pin to provide the distinct advantages of the DM7837 receiver design in existing systems. Performance is optimized for systems with bus rise and fall times $\leq 10\mu s$.

features

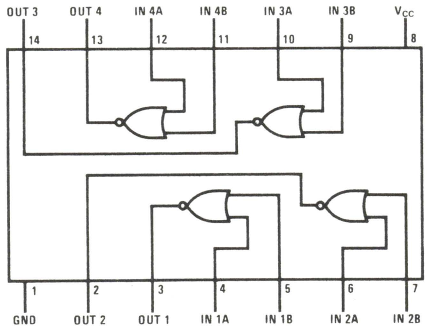
- Plug-in replacement for SP380 gate
- Low input current with normal V_{CC} or $V_{CC} = 0V$ (15 μA typ)
- Built-in input hysteresis (1V typ)
- High noise immunity (2V typ)
- Temperature-insensitive input thresholds track bus logic levels
- DTL/TTL compatible output
- Matched, optimized noise immunity for "1" and "0" levels
- High speed (18 ns typ)

typical application



connection diagram

Dual-In-Line and Flat Package



TOP VIEW

Order Number DM7836F
See Package 4

Order Number DM7836J
See Package 16

Order Number DM8836N
See Package 22

8

absolute maximum ratings (Note 1)

Supply Voltage	7.0V
Input Voltage	5.5V
Power Dissipation	600 mW
Operating temperature range:	
DM7836	−55°C to +125°C
DM8836	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$, unless otherwise specified (Note 2)

PARAMETER	INPUT	OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
High Level Input Threshold:							
DM7836	V_{TH}	16 mA	Output < 0.4V	1.85	2.25	2.65	V
DM8836	V_{TH}	16 mA	Output < 0.4V	2.00	2.25	2.50	V
Low Level Input Threshold:							
DM7836	V_{TH}	−400 μA	Output > 2.4V	1.03	1.30	1.57	V
DM8836	V_{TH}	−400 μA	Output > 2.4V	1.10	1.30	1.50	V
Maximum Input Current	4V		$V_{CC} = V_H$		15	50	μA
Maximum Input Current	4V		$V_{CC} = 0V$		1	50	μA
Logic "1" Output Voltage	0.5V	−400 μA		2.4			V
Logic "0" Output Voltage	4V	16 mA			0.25	0.4	V
Output Short Circuit Current	0.5V	0V	$V_{CC} = V_H$	−18		−55	mA
Power Supply Current	4V		Per Package		25	40	mA
Input Clamp Diode Voltage	−12 mA		$T_A = 25°C$		−1	−1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25°C$ unless otherwise specified.							
Propagation Delays:							
Input to Logic "1" Output			Note 3		20	30	ns
Input to Logic "0" Output			Note 4		18	30	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the reference pin.
Note 2: For DM7836: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55°C$, $T_H = +125°C$.
For DM8836: $V_L = 4.75V$, $V_H = 5.25V$, $T_L = 0°C$, $T_H = +70°C$.
Note 3: Fan-out of 10 load, $C_{LOAD} = 15$ pF total, measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.
Note 4: Fan-out of 10 load, $C_{LOAD} = 15$ pF total, measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Interface Circuits

DM7837/DM8837 hex unified bus receiver

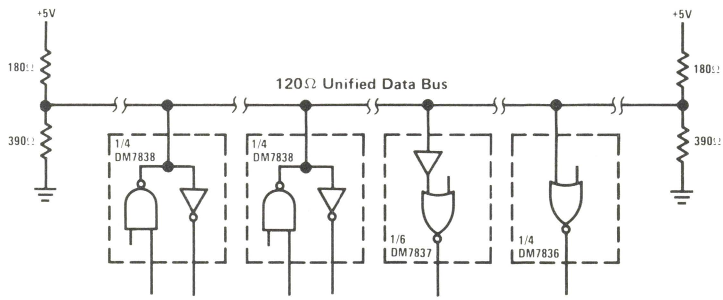
general description

The DM7837/DM8837 are high speed receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The receiver design employs a built-in input hysteresis providing substantial noise immunity. Low input current allows up to 27 driver/receiver pairs to utilize a common bus. Disable inputs provide time discrimination. Disable inputs and receiver outputs are DTL/TTL compatible. Performance is optimized for systems with bus rise and fall times ≤ 10µs.

features

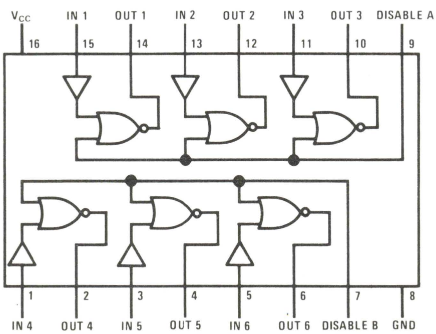
- Low receiver input current for normal V_{CC} or V_{CC} = 0V (15 µA typ)
- Six separate receivers per package
- Built-in receiver input hysteresis (1V typ)
- High receiver noise immunity (2V typ)
- Temperature insensitive receiver input thresholds track bus logic levels
- DTL/TTL compatible disable and output
- Molded or cavity dual-in-line or flat package
- High speed

typical application



connection diagram

Dual-In-Line and Flat Package



TOP VIEW

Order Number DM7837F	**Order Number DM7837J**	**Order Number DM8837N**
See Package 5	**See Package 17**	**See Package 23**

absolute maximum ratings (Note 1)

Supply Voltage	7V
Input Voltage	5.5V
Power Dissipation	600 mW
Operating Temperature Range	
DM7837	−55°C to +125°C
DM8837	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$, unless otherwise specified (Note 2)

PARAMETER	RECEIVER INPUT	DISABLE INPUT	OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
High Level Receiver Threshold: DM7837	V_{TH}	0.8V	16 mA	Output < 0.4V	1.85	2.25	2.65	V
High Level Receiver Threshold: DM8837	V_{TH}	0.8V	16 mA	Output < 0.4V	2.00	2.25	2.50	V
Low Level Receiver Threshold: DM7837	V_{TH}	0.8V	−400 mA	Output > 2.4V	1.03	1.30	1.57	V
Low Level Receiver Threshold: DM8837	V_{TH}	0.8V	−400 mA	Output > 2.4V	1.10	1.30	1.50	V
Maximum Receiver Input Current	4V			$V_{CC} = V_H$		15.0	50.0	μA
Maximum Receiver Input Current	4V			$V_{CC} = 0V$		1.0	50.0	μA
Logic "1" Input Voltage: Disable	0.5V	V_{IN}	16 mA	Output < 0.4V	2.0			V
Logic "0" Input Voltage: Disable	0.5V	V_{IN}	−400 μA	Output > 2.4V			0.8	V
Logic "1" Output Voltage	0.5V	0.8V	−400 μA		2.4			V
Logic "0" Output Voltage	4V	0.8V	16 mA			0.25	0.4	V
Logic "1" Input Current: Disable		2.4V					80.0	μA
Logic "1" Input Current: Disable		5.5V					2.0	mA
Logic "0" Input Current: Disable	4V	0.4V					−3.2	mA
Output Short Circuit Current	0.5V	0V	0V	$V_{CC} = V_H$	−18.0		−55.0	mA
Power Supply Current	4V	0V		Per Package		45.0	60.0	mA
Input Clamp Diode	−12 mA	−12 mA		$T_A = 25°C$		−1.0	−1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25°C$ unless otherwise specified.								
Propagation Delays:								
Receiver Input to Logic "1" Output		0V		Note 3		20	30	ns
Receiver Input to Logic "0" Output		0V		Note 4		18	30	ns
Disable Input to Logic "1" Output	0V			Note 5		9	15	ns
Disable Input to Logic "0" Output	0V			Note 5		4	10	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.
Note 2: For DM7837: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55°C$, $T_H = +125°C$
For DM8837: $V_L = 4.75V$, $V_H = 5.25V$, $T_L = 0°C$, $T_H = +70°C$
Note 3: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.
Note 4: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.
Note 5: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.5V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Interface Circuits

DM7838/DM8838 quad unified bus transceiver

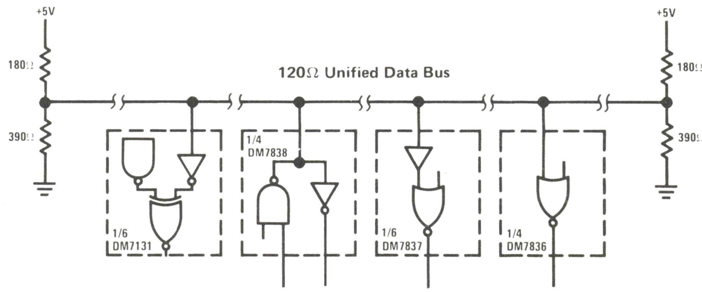
general description

The DM7838/DM8838 are quad high speed drivers/receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be a 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The bus can be terminated at one or both ends. Low bus pin current allows up to 27 driver/receiver pairs to utilize a common bus. The bus loading is unchanged when V_{CC} = 0V. The receivers incorporate hysteresis to greatly enhance bus noise immunity. One two-input NOR gate is included to disable all drivers in a package simultaneously. Receiver performance is optimized for systems with bus rise and fall times ≤ 10μs.

features

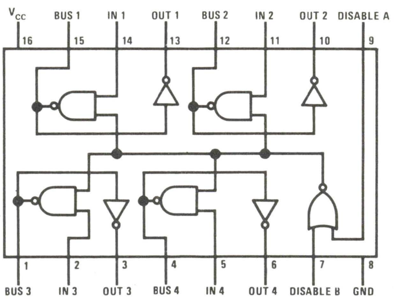
- 4 totally separate driver/receiver pairs per package
- 1V typical receiver input hysteresis
- Receiver hysteresis independent of receiver output load
- Guaranteed minimum bus noise immunity of 1.3V, 2V typ.
- Temperature-insensitive receiver thresholds track bus logic levels
- 20μA typical bus terminal current with normal V_{CC} or with V_{CC} = 0V
- Open collector driver output allows wire-OR connection
- High speed
- Series 74 TTL compatible driver and disable inputs and receiver outputs

typical application



connection diagram

Dual In-Line and Flat Package



TOP VIEW

Order Number DM7838F
See Package 5

Order Number DM7838J
See Package 17

Order Number DM8838
See Package 23

absolute maximum ratings

Supply Voltage	7V
Input and Output Voltage	5.5V
Power Dissipation	600 mW
Operating Temperature Range	
DM7838	-55°C to +125°C
DM8838	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

DM7838/DM8838: The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$ unless otherwise specified (Note 2).

PARAMETER	DISABLE INPUT	DRIVER INPUT	BUS PIN	RECEIVER OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
Logic "1" Input Voltage: Disable	V_{IN}	2V	4V		Bus < 100 µA	2.0			V
Logic "0" Input Voltage: Disable	V_{IN}	2V	50 mA		Bus < 0.7V			0.8	V
Logic "1" Input Voltage: Driver	0.8V	V_{IN}	50 mA		Bus < 0.7V	2.0			V
Logic "0" Input Voltage: Driver	0.8V	V_{IN}	4V		Bus < 100 µA			0.8	V
High Level Receiver Threshold: DM7838		0.8V	V_{TH}	16 mA	Receiver output < 0.4V	1.85	2.25	2.65	V
High Level Receiver Threshold: DM8838		0.8V	V_{TH}	16 mA	Receiver output < 0.4V	2.00	2.25	2.50	V
Low Level Receiver Threshold: DM7838		0.8V	V_{TH}	-400 µA	Receiver output > 2.4V	1.03	1.30	1.57	V
Low Level Receiver Threshold: DM8838		0.8V	V_{TH}	-400 µA	Receiver output > 2.4V	1.10	1.30	1.50	V
Logic "1" Input Current: Disable and Driver	5.5V	5.5V						1	mA
Logic "1" Input Current: Disable and Driver	2.4V	2.4V						40	µA
Logic "0" Input Current: Disable and Driver	0.4V	0.4V						-1.6	mA
Maximum Bus Current	0.8V	0.8V	4V		$V_{CC} = V_H$		20	100	µA
Maximum Bus Current	0.8V	0.8V	4V		$V_{CC} = 0V$		2	100	µA
Low Level Bus Voltage	0.8V	2V	50 mA				0.4	0.7	V
Logic "1" Output Voltage: Receiver	0.8V	0.8V	0.5V	-400 µA		2.4			V
Logic "0" Output Voltage: Receiver	0.8V	0.8V	4V	16 mA			0.25	0.4	V
Output Short Circuit Current: Receiver	0.8V	0.8V	0.5V	0V	$V_{CC} = V_H$	-18		-55	mA
Supply Current	0V	2V			Per Package		50	70	mA
Input Diode Clamp Voltage	-12 mA	-12 mA	-12 mA		$T_A = 25°C$		-1	-1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25°C$ unless otherwise specified.									
Propagation Delays:									
Disable to Bus "1"					Note 3		19	30	ns
Disable to Bus "0"					Note 3		15	23	ns
Driver Input to Bus "1"					Note 3		17	25	ns
Driver Input to Bus "0"					Note 3		9	15	ns
Bus to Logic "1" Receiver Output					Note 4		20	30	ns
Bus to Logic "0" Receiver Output					Note 5		18	30	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: For DM7838: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55°C$, $T_H = 125°C$.
For DM8838: $V_L = 4.75V$, $V_H = 5.25$, $T_L = 0°C$, $T_H = 70°C$.

Note 3: 91Ω from bus pin to V_{CC} and 200Ω from bus pin to ground, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.5V$ to $V_{BUS} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 4: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 5: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Display Drivers

DM75491 MOS-to-LED quad segment driver
DM75492 MOS-to-LED hex digit driver

general description

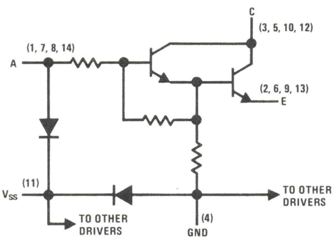
The DM75491 and DM75492 are interface circuits designed to be used in conjunction with MOS integrated circuits and common-cathode LED's in serially addressed multi-digit displays. The number of drivers required for this time-multiplexed system is minimized as a result of the segment-address-and-digit-scan method of LED drive.

features

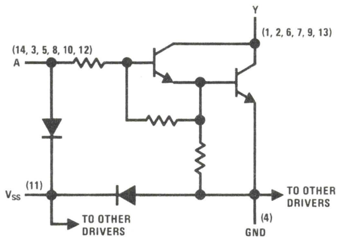
- Source or sink capability per driver (DM75491) 50 mA
- Sink capability per driver (DM75492) 250 mA
- MOS compatability (low input current)
- Low standby power
- High-gain Darlington circuits

schematic and connection diagrams

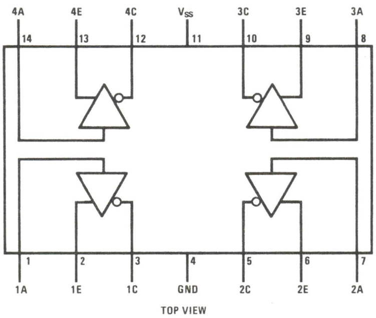
DM75491 (each driver)



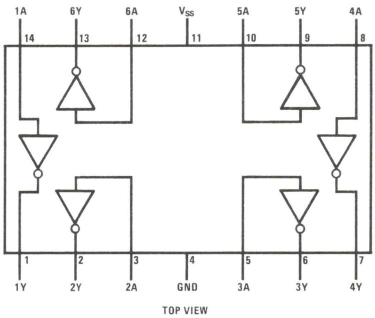
DM75492 (each driver)



DM75491 Dual-In-Line Package



DM75492 Dual-In-Line Package



Order Number DM75491N or DM75492N
See Package 22

absolute maximum ratings

	DM75491	DM75492
Input Voltage Range (Note 1)	$-5V$ to V_{SS}	$-5V$ to V_{SS}
Collector Output Voltage (Note 2)	10V	10V
Collector Output to Input Voltage	10V	10V
Emitter to Ground Voltage ($V_I \geq 5V$)	10V	
Emitter to Input Voltage	5V	
Voltage at V_{SS} Terminal With Respect to Any Other Device Terminal	10V	10V
Collector Output Current		
Each Collector Output	50 mA	250 mA
All Collector Outputs	200 mA	600 mA
Continuous Total Dissipation	800 mW	800 mW
Operating Temperature Range	0°C to +70°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C	300°C

dc electrical characteristics

DM75491 (V_{SS} = 10V, T_A = 0°C to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 kΩ, V_E = 5V, I_C = 50 mA, T_A = 25°C		.9	1.2	V
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 kΩ, V_E = 5V, I_C = 50 mA			1.5	V
Off State Collector Current ($I_{C\ OFF}$)	V_C = 10V, V_E = 0, I_{IN} = 40μA			100	μA
Off State Collector Current ($I_{C\ OFF}$)	V_C = 10V, V_E = 0, V_{IN} = .7V			100	μA
Input Current at Maximum Input Voltage (I_I)	V_{IN} = 10V, V_E = 0, I_C = 20 mA		2.2	3.3	mA
Emitter Reverse Current (I_E)	V_{IN} = 0, V_E = 5V, I_C = 0			100	μA
Current Into V_{SS} Terminal (I_{SS})				1	mA

DM75492 (V_{SS} = 10V, T_A = 0°C to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Low Level Output Voltage (V_{OL})	Input = 6.5V through 1 kΩ, I_{OUT} = 250 mA T_A = 25°C		.9	1.2	V
Low Level Output Voltage (V_{OL})	Input = 6.5V through 1 kΩ, I_{OUT} = 250 mA			1.5	V
High Level Output Current (I_{OH})	V_{OH} = 10V, I_{IN} = 40μA			200	μA
High Level Output Current (I_{OH})	V_{OH} = 10V, V_{IN} = .5V			200	μA
Input Current at Maximum Input Voltage (I_I)	V_{IN} = 10V, I_{OL} = 20 mA		2.2	3.3	mA
Current Into V_{SS} Terminal (I_{SS})				1	mA

ac switching characteristics

DM75491 (V_{SS} = 7.5V, T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level Output (Collector) (t_{PLH})	V_{IH} = 4.5V, V_E = 0,		100		ns
Propagation Delay Time, High to Low Level Output (Collector) (t_{PHL})	R_L = 200Ω, C_L = 15 pF		20		ns

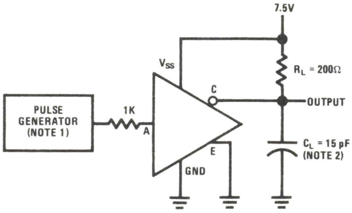
DM75492 (V_{SS} = 7.5V, T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level Output (t_{PLH})	V_{IH} = 7.5V, R_L = 39Ω,		300		ns
Propagation Delay Time, High to Low Level Output (t_{PHL})	C_L = 15 pF		30		ns

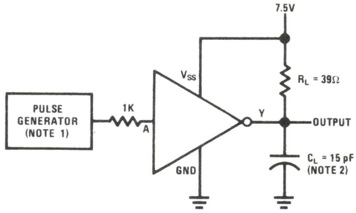
Note 1: The input is the only device terminal which may be negative with respect to ground.

Note 2: Voltage values are with respect to network ground terminal unless otherwise noted.

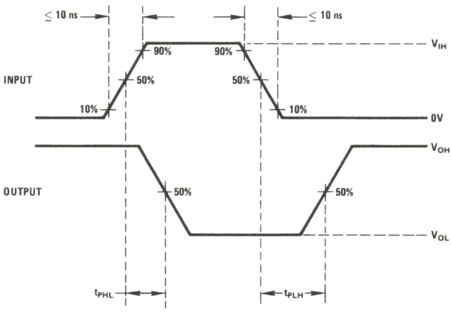
ac test circuits and switching time waveforms



DM75491



DM75492



NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: $Z_{OUT} = 50\Omega$, PRR = 100 KHz, $t_W = 1\mu s$.

NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.

9

Display Drivers

DM8861 MOS-to-LED 5-segment driver
DM8863 MOS-to-LED 8-digit driver

general description

The DM8861 and DM8863 are designed to be used in conjunction with MOS integrated circuits and common-cathode LED's in serially addressed multi-digit displays.

The DM8861 is a 5-segment driver capable of sinking or sourcing up to 50 mA from each driver.

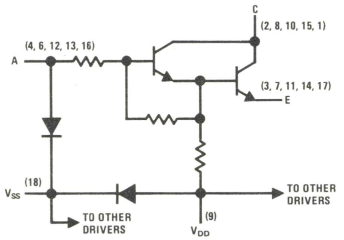
The DM8863 is an 8-digit driver. Each driver is capable of sinking up to 500 mA.

features

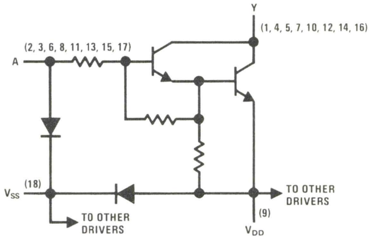
- Source or sink capability per driver, DM8861 — 50 mA
- Sink capability per driver, DM8863 — 500 mA
- MOS compatibility (low input current)
- Low standby power
- High gain Darlington circuits

schematic and connection diagrams

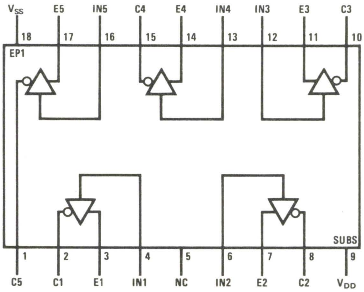
DM8861



DM8863

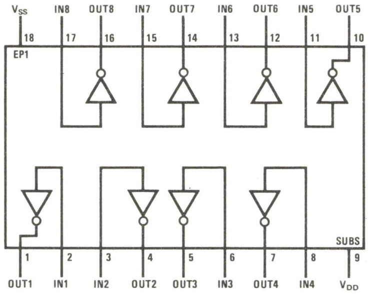


Dual-In-Line Package



TOP VIEW

Dual-In-Line Package



TOP VIEW

Order Numbers DM8861N or DM8863N
See Package 29

absolute maximum ratings

	DM8861	DM8863
Input Voltage Range (Note 1)	$-5V$ to V_{SS}	$-5V$ to V_{SS}
Collector (Output) Voltage (Note 2)	10V	10V
Collector (Output)-to-Input Voltage	10V	10V
Emitter-to-Ground Voltage ($V_I \geq 5V$)	10V	
Emitter-to-Input Voltage	5V	
Voltage at V_{SS} Terminal With Respect to Any Other Device Terminal	10V	10V
Collector (Output) Current		
Each Collector (Output)	50 mA	500 mA
All Collectors (Output)	200 mA	600 mA
Continuous Total Dissipation	800 mW	800 mW
Operating Temperature Range	0°C to +70°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C	300°C

dc electrical characteristics

DM8861 (V_{SS} = 10V, T_A = 0°C to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 kΩ, V_E = 5V, I_C = 50 mA, T_A = 25°C		.9	1.2	V
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 kΩ, V_E = 5V, I_C = 50 mA			1.5	V
Off State Collector Current ($I_{C\ OFF}$)	V_C = 10V, V_E = 0, I_{IN} = 40μA			100	μA
Off Set Collector Current ($I_{C\ OFF}$)	V_C = 10V, V_E = 0, V_{IN} = .7V			100	μA
Input Current at Maximum Input Voltage (I_I)	V_{IN} = 10V, V_E = 0, I_C = 20 mA		2.2	3.3	mA
Emitter Reverse Current (I_E)	V_{IN} = 0, V_E = 5V, I_C = 0			100	μA
Current Into V_{SS} Terminal (I_{SS})				1	mA

DM8863 (V_{SS} = 10V, T_A = 0°C to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Low Level Output Voltage (V_{OL})	V_{IN} = 7V, I_{OUT} = 500 mA, T_A = 25°C			1.5	V
Low Level Output Voltage (V_{OL})	V_{IN} = 7V, I_{OUT} = 500 mA			1.6	V
High Level Output Current (I_{OH})	V_{OH} = 10V, I_{IN} = 40μA			250	μA
High Level Output Current (I_{OH})	V_{OH} = 10V, V_{IN} = .5V			250	μA
Input Current at Maximum Input Voltage (I_I)	V_{IN} = 10V, I_{OL} = 20 mA			2	mA
Current Into V_{SS} Terminal (I_{SS})				1	mA

ac switching characteristics

DM8861 (V_{SS} = 7.5V, T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay Time, Low to High Level Output (Collector) (t_{PLH})	V_{IH} = 4.5V, V_E = 0		100		ns
Propagation Delay Time, High to Low Level Output (Collector) (t_{PHL})	R_L = 200Ω, C_L = 15 pF		20		ns

DM8863 (V_{SS} = 7.5V, T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay Time, Low to High Level Output (t_{PLH})	V_{IH} = 8V, R_L = 21Ω,		300		ns
Propagation Delay Time, High to Low Level Output (t_{PHL})	C_L = 15 pF		30		ns

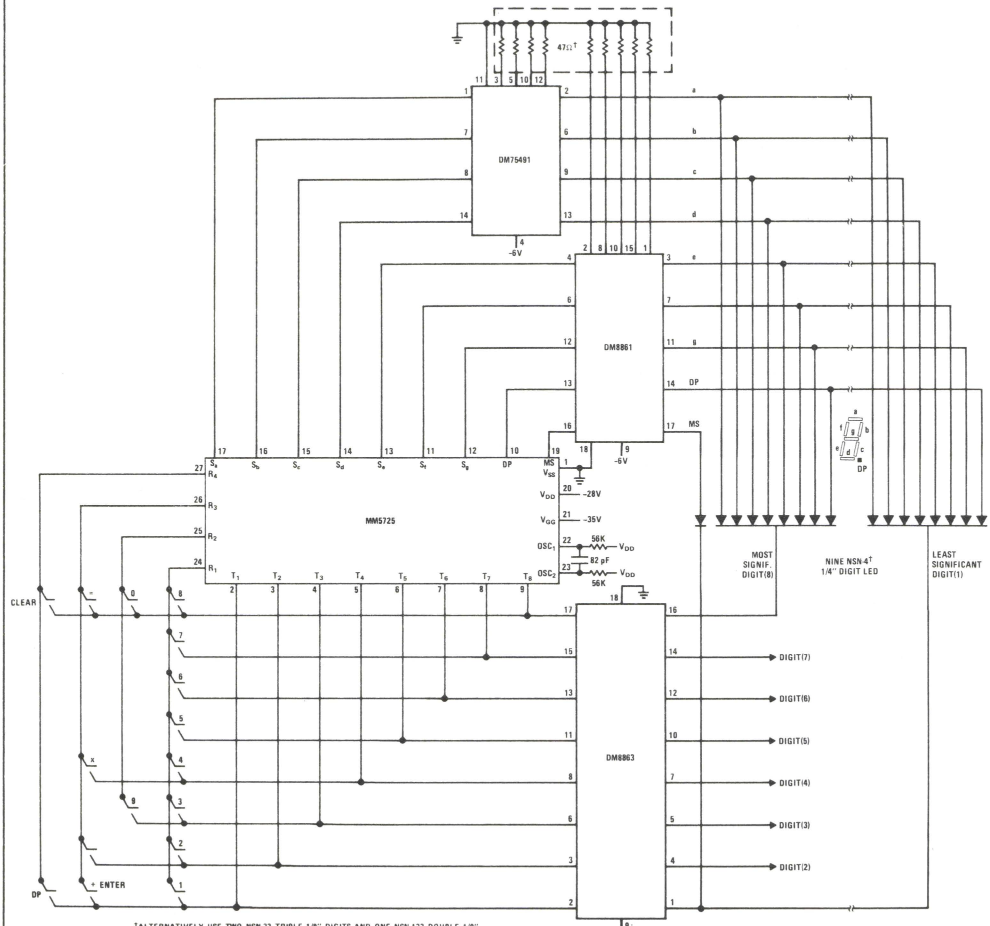
Note 1: The input is the only device terminal which may be negative with respect to ground.

Note 2: Voltage values are with respect to network ground terminal unless otherwise noted.

9

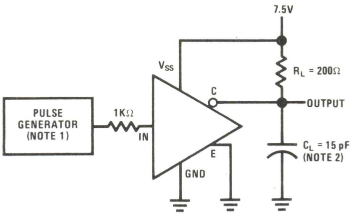
typical application

8-Digit Calculator With LED Display

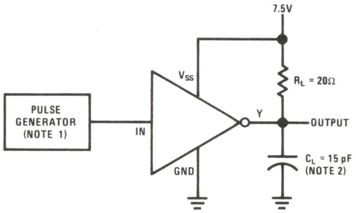


†ALTERNATIVELY USE TWO NSN-33 TRIPLE 1/8" DIGITS AND ONE NSN-133 DOUBLE 1/8" DIGIT WITH SEPARATE MINUS SIGN, AND CHANGE RESISTOR VALUES TO 100Ω.

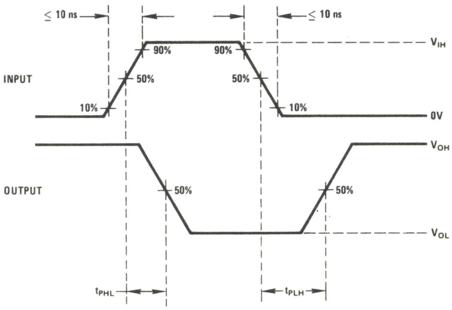
ac test circuits and waveforms



DM8861



DM8863



NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: $Z_{OUT} = 50\Omega$, PRR = 100 KHz, $t_W = 1\mu s$.

NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.

Display Drivers

DM7880/DM8880 high voltage 7-segment decoder/driver (for driving Sperry and Panaplex II™ displays)

general description

The DM7880/DM8880 is custom designed to decode four lines of BCD and drive a gas-filled seven-segment display tube.

The design employs a 112-bit read-only memory which provides BCD input to full hexadecimal output decoding in the standard DM7880/DM8880 product. For applications desiring other fonts, or not using standard BCD coding, the ROM contents can be custom modified to produce any 16 output displays for the 16 binary input combinations.

Each output constitutes a switchable, adjustable current sink which provides constant current to the tube segment, even with high tube anode supply tolerance or fluctuation. These current sinks have a voltage compliance from 3V to at least 80V; typically the output current varies 1% for output voltage changes of 3 to 50V. Each bit line of the ROM switches a current sink on or off as prescribed by the input code. Each current sink is ratioed to the b-output current as required for even illumination of all segments.

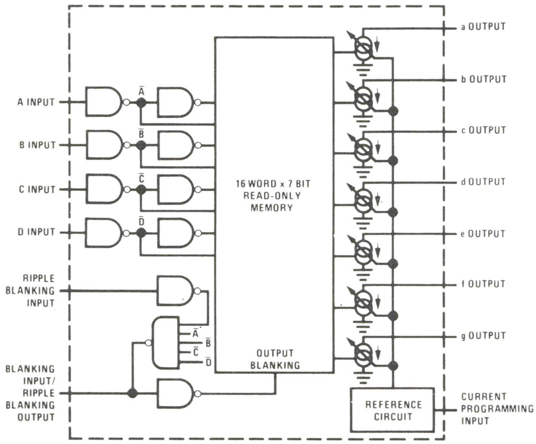
Output currents may be varied over the 0.2 to 1.5 mA range for driving various tube types or multiplex operation. The output current is adjusted by connecting an external program resistor (R_P) from V_{CC} to the Program input in accordance with the programming curve. The circuit design provides a one-to-one correlation between program input current and b-segment output current.

The Blanking Input provides unconditional blanking of any output display, while the Ripple Blanking pins allow simple leading- or trailing-zero blanking.

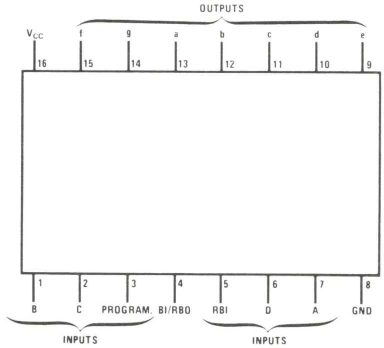
features

- Current sink outputs
- Adjustable output current – 0.2 to 1.5 mA
- High output breakdown voltage – 110V typ
- Suitable for multiplex operation
- Blanking and Ripple Blanking provisions
- Low fan-in and low power

logic and connection diagrams



Dual-In-Line Package



TOP VIEW

Order Number DM7880J
See Package 17

Order Number DM8880N
See Package 23

absolute maximum ratings

V_{CC}	7V
Input Voltage (Except BI)	6V
Input Voltage (BI)	V_{CC}
Segment Output Voltage	80V
Power Dissipation (Note 1)	600 mW
Transient Segment Output Current (Note 2)	50 mA
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

operating conditions

	MIN	MAX	UNITS
Supply Voltage (V_{CC})			
DM7880	4.5	5.5	V
DM8880	4.75	5.25	V
Temperature (T_A)			
DM7880	−55	+125	°C
DM8880	0	+70	°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logic "1" Input Voltage	V_{CC} = Min	2.0			V
Logic "0" Input Voltage	V_{CC} = Min			0.8	V
Logic "1" Output Voltage (RBO)	V_{CC} = Min, I_{OUT} = −200 μA	2.4	3.7		V
Logic "0" Output Voltage (RBO)	V_{CC} = Min, I_{OUT} = 8 mA		0.13	0.4	V
Logic "1" Input Current (Except BI)	V_{CC} = Max, V_{IN} = 2.4V		2	15	μA
	V_{CC} = Max, V_{IN} = 5.5V		4	400	μA
Logic "0" Input Current (Except BI)	V_{CC} = Max, V_{IN} = 0.4V		−300	−600	μA
Logic "0" Input Current (BI)	V_{CC} = Max, V_{IN} = 0.4V		−1.2	−2.0	mA
Power Supply Current	V_{CC} = Max, R_P = 2.2k All Inputs = 0V		27	43	mA
Input Diode Clamp Voltage	V_{CC} = Max, T_A = 25°C I_{IN} = −12 mA		−0.9	−1.5	V
Segment Outputs:					
Outputs a, f, g ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.84	0.93	1.02	
Output c ON Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	1.12	1.25	1.38	
Output d ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.90	1.00	1.10	
Output e ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.99	1.10	1.21	
Output b ON Current	V_{CC} = 5V, V_{OUT} b = 50V T_A = 25°C, R_P = 18.1k	0.18	0.20	0.22	mA
	V_{CC} = 5V, V_{OUT} b = 50V T_A = 25°C, R_P = 7.03k	0.45	0.50	0.55	mA
	V_{CC} = 5V, V_{OUT} b = 50V T_A = 25°C, R_P = 3.40k	0.90	1.00	1.10	mA
	V_{CC} = 5V, V_{OUT} b = 50V T_A = 25°C, R_P = 2.20k	1.35	1.50	1.65	mA
Output Saturation Voltage	V_{CC} = Min, R_P = 1k±5% I_{OUT} b = 2 mA (Note 4)		0.8	2.5	V
Output Leakage Current	V_{OUT} = 75V, BI = 0V		.003	3	μA
Output Breakdown Voltage	I_{OUT} = 250 μA, BI = 0V	80	110		V
Propagation Delays:					
BCD Input to Segment Output	V_{CC} = 5V, T_A = 25°C		0.4	10	μs
BI to Segment Output	V_{CC} = 5V, T_A = 25°C		0.4	10	μs
RBI to Segment Output	V_{CC} = 5V, T_A = 25°C		0.7	10	μs
RBI to RBO	V_{CC} = 5V, T_A = 25°C		0.4	10	μs

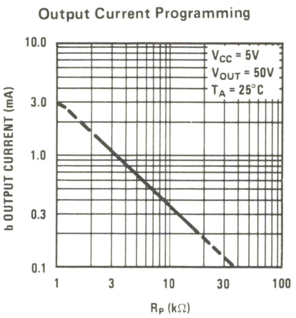
Note 1: Maximum junction temperature for DM7880 is 150°C whereas that for DM8880 is 130°C. For operating at elevated temperatures the device must be derated based on a thermal resistance of 85°C/W Θ_{JA} for DM7880 and 150°C/W Θ_{JA} for DM8880.

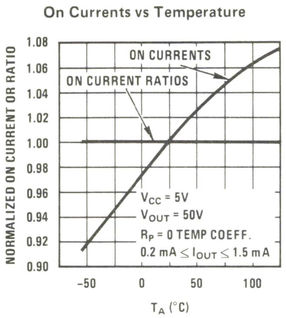
Note 2: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

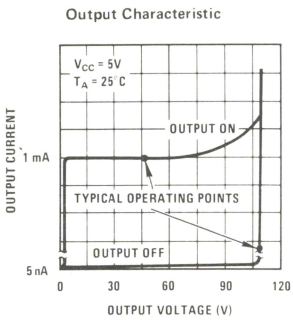
Note 3: Min/max limits apply across the guaranteed operating temperature range of −55°C to 125°C for DM7880 and 0°C to 70°C for DM8880, unless otherwise specified. Typicals are for V_{CC} = 5V, T_A = 25°C. Positive current is defined as current into the referenced pin.

Note 4: For saturation mode the segment output currents are externally limited and ratioed.

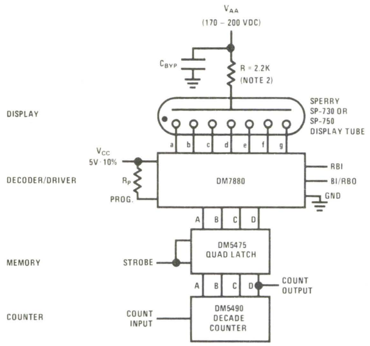
typical performance characteristics





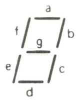


typical application



truth table

DECIMAL OR FUNCTION	RBI	D	C	B	A	BI/RBO	a	b	c	d	e	f	g	DISPLAY
0	1	0	0	0	0	1	0	0	0	0	0	0	1	
1	X	0	0	0	1	1	1	0	0	1	1	1	1	
2	X	0	0	1	0	1	0	0	1	0	0	1	0	
3	X	0	0	1	1	1	0	0	0	0	1	1	0	
4	X	0	1	0	0	1	1	0	0	1	1	0	0	
5	X	0	1	0	1	1	0	1	0	0	1	0	0	
6	X	0	1	1	0	1	0	1	0	0	0	0	0	
7	X	0	1	1	1	1	0	0	0	1	1	1	1	
8	X	1	0	0	0	1	0	0	0	0	0	0	0	
9	X	1	0	0	1	1	0	0	0	0	1	0	0	
10	X	1	0	1	0	1	0	0	0	1	0	0	0	
11	X	1	0	1	1	1	1	1	0	0	0	0	0	
12	X	1	1	0	0	1	0	1	1	0	0	0	1	
13	X	1	1	0	1	1	1	0	0	0	0	1	0	
14	X	1	1	1	0	1	0	1	1	0	0	0	0	
15	X	1	1	1	1	1	0	1	1	1	0	0	0	
BI	X	X	X	X	X	0	1	1	1	1	1	1	1	
RBI	0	0	0	0	0	0	1	1	1	1	1	1	1	



SEGMENT IDENTIFICATION

Display Drivers

DM8884A high voltage cathode decoder/driver (for driving Panaplex II™ and Sperry displays)

general description

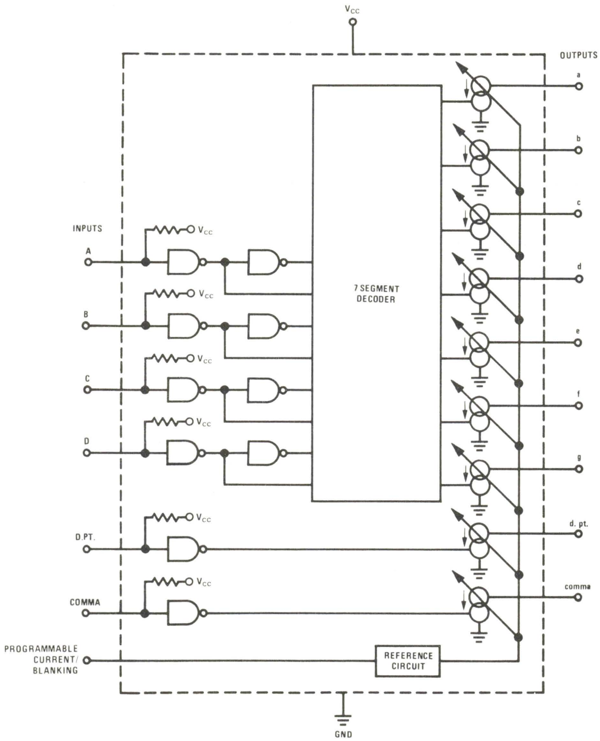
The DM8884A is designed to decode four lines of BCD input and drive seven-segment digits of gas-filled readout displays. Two separate inputs are provided for driving the decimal point and comma cathodes.

All outputs consist of switchable and programable current sinks which provide constant current to the tube cathodes, even with high tube anode supply tolerance. Output currents may be varied over the 0.2 to 1.2 mA range for multiplex operation. The output current is adjusted by connecting an external program resistor (R_P) from V_{CC} to the program input in accordance with the programming curve.

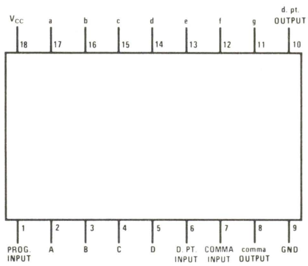
features

- Usable with AC or DC input coupling
- Current sink outputs
- High output breakdown voltage
- Low input load current
- Intended for multiplex operation.
- Input pullups increase noise immunity

logic and connection diagrams



Dual-In-Line Package



TOP VIEW

Order Number DM8884AN
See Package 29

absolute maximum ratings

V_{CC}	7V
Input Voltage (Note 1)	V_{CC}
Segment Output Voltage	80V
Power Dissipation (Note 2)	600 mW
Transient Segment Output Current (Note 3)	50 mA
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

electrical characteristics (0°C ≤ T_A ≤ 70°C – Unless otherwise noted), V_{CC} = 5V ± 5%.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
Logic "1" Input Voltage	V_{CC} = 4.75V	2.0		V
Logic "0" Input Voltage	V_{CC} = 4.75V		1.0	V
Logic "1" Input Current	V_{CC} = 5.25V, V_{IN} = 2.4V		15	μA
Positive Input Clamp Voltage	V_{CC} = 4.75, I_{IN} = 1 mA	5.0		V
Logic "0" Input Current	V_{CC} = 5.25V, V_{IN} = 0.4V		−250	μA
Power Supply Current	V_{CC} = 5.25V, R_P = 2.8k, All Inputs = 5V		40	mA
Negative Input Clamp Voltage	V_{CC} = 5V, I_{IN} = −12 mA, T_A = 25°C		−1.5	V
Segment Outputs:				
All Outputs ON Current Ratio	All Outputs = 50V Output b Current = Ref.	0.9	1.1	
Output b ON Current	V_{CC} = 5V, V_{OUT} b = 50V,			
	T_A = 25°C, R_P = 18.1k	0.18	0.22	mA
	R_P = 7.03k	0.45	0.55	mA
	R_P = 3.40k	0.90	1.10	mA
	R_P = 2.80k	1.08	1.32	mA
Output Leakage Current	V_{OUT} = 75V		5	μA
Output Breakdown Voltage	I_{OUT} = 250 μA	80		V
Propagation Delay:				
Any Input to Segment Output	V_{CC} = 5V, T_A = 25°C		10	μs

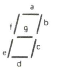
Note 1: This limit can be higher for a current limiting voltage source.

Note 2: The maximum junction temperature is 140°C. For operation at elevated temperatures, the device must be derated based on a thermal resistance of 140°C/W θ_{JA}.

Note 3: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

truth table

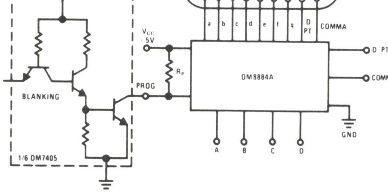
FUNCTION	D.PT.	COMMA	D	C	B	A	a	b	c	d	e	f	g	DISPLAY
0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	1	1	0	0	1	1	1	1	1
2	1	1	0	0	1	0	0	0	1	0	0	1	0	2
3	1	1	0	0	1	1	0	0	0	0	1	1	0	3
4	1	1	0	1	0	0	1	0	0	1	1	0	0	4
5	1	1	0	1	0	1	0	1	0	0	1	0	0	5
6	1	1	0	1	1	0	0	1	0	0	0	0	0	6
7	1	1	0	1	1	1	0	0	0	1	1	1	1	7
8	1	1	1	0	0	0	0	0	0	0	0	0	0	8
9	1	1	1	0	0	1	0	0	0	0	1	0	0	9
10	1	1	1	0	1	0	1	1	0	0	0	1	1	
11	1	1	1	0	1	1	1	1	0	0	0	1	0	
12	1	1	1	1	0	0	0	0	1	1	1	0	0	
13	1	1	1	1	0	1	0	1	1	0	0	0	0	
14	1	1	1	1	1	0	1	1	1	1	1	1	0	
15	1	1	1	1	1	1	1	1	1	1	1	1	1	
*D.PT.	0	1	X	X	X	X	X	X	X	X	X	X	X	.
*Comma	0	0	X	X	X	X	X	X	X	X	X	X	X	,



Decimal Point
Comma

*Decimal point and comma can be displayed with or without any numeral.

typical application



typical performance characteristics (see DM7880 data sheet)

Display Drivers

DM8885 MOS to high voltage cathode buffer

general discription

The DM8885 interfaces MOS calculator or counter-latch-decoder-driver circuits directly to seven-segment high-voltage gas-filled displays. The six inputs A, B, D, E, F, G are decoded to drive the seven segments of the tube.

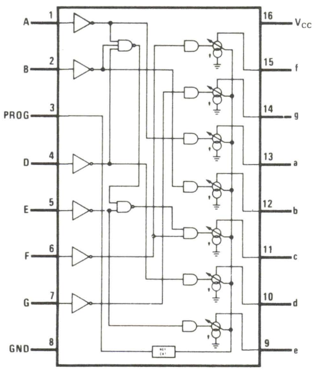
Each output constitutes a switchable, adjustable current source which provides constant current to the tube segment, even with high tube anode supply tolerance or fluctuation. These current sources have a voltage compliance from 3V to at least 80V. Each current source is ratioed to the b-output current as required for even illumination of all segments. Output currents may be varied over the 0.2 to 1.5 mA range for driving various tube types or multiplex operation. The output current is adjusted by connecting a program resistor (R_P) from V_{CC} to the program input.

features

- Current source outputs
- Adjustable output currents 0.2 to 1.5 mA
- High output breakdown voltage 80V min
- Suitable for multiplex operation
- Low fan-in and low power
- Blanking via program input
- Also drives overrange, polarity, decimal point cathodes

connection diagram

Dual-In-Line Package



TOP VIEW

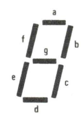
Order Number DM8885
See Package 23

truth tables

A	B	D	E	F	G	DISPLAY
1	1	1	1	1	0	0
0	1	0	0	0	0	1
1	1	1	1	0	1	2
1	1	1	0	0	1	3
0	1	0	0	1	1	4
1	0	1	0	1	1	5
1	0	1	1	1	1	6
1	1	0	0	0	0	7
1	1	1	1	1	1	8
1	1	1	0	1	1	9
0	0	1	1	1	1	b
1	1	0	0	1	1	q
1	1	0	1	1	1	A
0	1	0	1	1	1	H
0	1	1	1	1	0	U
0	0	0	0	0	1	8
0	0	0	0	0	0	

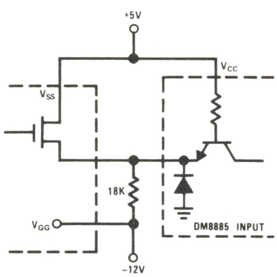
INPUT*	OUTPUT*
0	1 (OFF)
1	0 (ON)

*Positive Logic

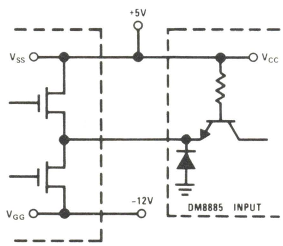


$C = (\overline{A} \cdot \overline{B} \cdot \overline{D} + E)\,\overline{F}$

typical applications



Open-Drain MOS Output



Push-Pull MOS Output

9

absolute maximum ratings

V_{CC}	7V
Input Voltage	6V
Segment Output Voltage	80V
Power Dissipation (Note 1)	600 mW
Transient Segment Output Current (Note 2)	50 mA
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logic "1" Input Voltage	V_{CC} = 4.75V	2.0			V
Logic "0" Input Voltage	V_{CC} = 4.75V			0.8	V
Logic "1" Input Current	V_{CC} = 5.25V, V_{IN} = 2.4V		2	15	μA
	V_{CC} = 5.25V, V_{IN} = 5.5V		4	400	μA
Logic "0" Input Current	V_{CC} = 5.25V, V_{IN} = 0.4V		-300	-600	μA
Power Supply Current	V_{CC} = 5.25V, All Inputs = 0V, R_P = 2.2k		22	31	mA
Input Diode Clamp Voltage	V_{CC} = 5V, I_{IN} = −12 mA, T_A = 25°C		-0.9	-1.5	V
Segment Outputs:					
Outputs a, f, g On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.84	0.93	1.02	
Output c On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	1.12	1.25	1.38	
Output d On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.90	1.00	1.10	
Output e On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.99	1.10	1.21	
Output b On Current	V_{CC} = 5V, V_{OUT} b = 50V, T_A = 25°C, R_P = 18.1k	0.18	0.20	0.22	mA
	V_{CC} = 5V, V_{OUT} b = 50V, T_A = 25°C, R_P = 7.03k	0.45	0.50	0.55	mA
	V_{CC} = 5V, V_{OUT} b = 50V, T_A = 25°C, R_P = 3.40k	0.90	1.00	1.10	mA
	V_{CC} = 5V, V_{OUT} b = 50V, T_A = 25°C, R_P = 2.20k	1.35	1.50	1.65	mA
Output Saturation Voltage	V_{CC} = 4.75V, I_{OUT} b = 2 mA, R_P = 1k ± 5% (Note 4)		0.8	2.5	V
Output Leakage Current	V_{OUT} = 75V, V_{IN} = 0.8V, R_P > 1k		0.003	3	μA
	V_{OUT} = 75V, V_{PROG} = 0.4V		0.003	3	μA
Output Breakdown Voltage	I_{OUT} = 250 μA, V_{IN} = 0.8V	80	110		V
Propagation Delays:					
Input to Segment Output	V_{CC} = 5V, T_A = 25°C		0.4	10	μs

Note 1: Maximum junction temperature is 130°C. For operating at elevated temperatures, the device must be derated based on a thermal resistance of 150°C/W θ_{JA}.

Note 2: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

Note 3: Min/max limits apply across the guaranteed operating temperature range of 0°C to +70°C, unless otherwise specified. Typicals are for V_{CC} = 5V, T_A = 25°C. Positive current is defined as current into the referenced pin.

Note 4: For saturation mode the segment output currents are externally limited and ratioed.

typical performance characteristics (see DM7880 data sheet)

Sense Amplifiers

LM5520/LM7520 series
dual core memory sense amplifiers

general description

The devices in this series of dual core sense amplifiers convert bipolar millivolt-level memory sense signals to saturated logic levels. The design employs a common reference input which allows the input threshold voltage level of both amplifiers to be adjusted. Separate strobe inputs provide time discrimination for each channel. Logic inputs and outputs are DTL/TTL compatible. All devices of the series have identical preamplifier configurations, while various logic connections are provided to suit the specific application.

The LM5520/LM7520 has output latch capability and provides sense, strobe, and memory function for two sense lines. The LM5522/LM7522 contains a single open collector output which may be used to expand the number of inputs of the LM5520/LM7520, or to drive an external Memory Data Register (MDR). Intended for small memories, the two channels of the LM5524/LM7524 are independent with two separate outputs. The LM5534/LM7534 is similar to the LM5524/LM7524 but has uncommitted, wire-ORable outputs. The LM5528/LM7528 has the same logic configuration of the LM5524/LM7524 and in addition provides separate low impedance Test Points at each preamplifier output. A similar device having uncommitted, wire-ORable outputs is the LM5538/LM7538.

features

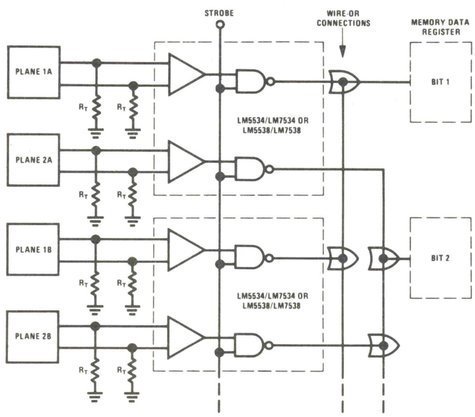
- High speed
- Guaranteed narrow threshold uncertainty over temperature
- Adjustable input threshold voltage
- Fast overload recovery times
- Two amplifiers per package
- Molded or cavity dual-in-line package
- Six logic configurations

The part number ending with an even number (e.g., LM5520) designates a tighter guaranteed input threshold uncertainty than the subsequent odd number ending (e.g., LM5521). The remaining specifications for the two are identical. All devices meet or exceed the specifications for the corresponding device (where applicable) in the SN5520/SN7520 series and are pin-for-pin replacements.

absolute maximum ratings

Supply Voltage		±7V
Differential or Reference Input Voltage		±5V
Logic Input Voltage		+5.5V
Operating Temperature Range	LM55XX	−55°C to +125°C
	LM75XX	0°C to +70°C
Storage Temperature Range		−65°C to +150°C

typical application



Expanded Small Memory System

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LM5520/LM7520 and LM5521/LM7521

electrical characteristics

LM5520/LM5521: The following apply for $-55°C \leq T_A \leq 125°C$

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	GATE Q INPUT	GATE $\bar{Q}$ INPUT	LOGIC OUTPUT (NOTE 3)	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V		+16 mA(Q)	±5V	Logic Output <0.4V
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V		−400 µA(Q)	±5V	Logic Output >2.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V		+16 mA(Q)	±5V	Logic Output <0.4V
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V		−400 µA(Q)	±5V	Logic Output >2.4V
Differential & Reference Input Bias Current		30	100	µA	0V	0V	+5.25V	+5.25V	+5.25V		±5.25V	
LM7520/LM7521: The following apply for $0°C \leq T_A \leq 70°C$												
Differential Input Threshold Voltage (V_{TH}) (Note 4)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V		+16 mA(Q)	±5V	Logic Output <0.4V
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V		−400 µA(Q)	±5V	Logic Output >2.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V		+16 mA(Q)	±5V	Logic Output <0.4V
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V		−400 µA(Q)	±5V	Logic Output >2.4V
Differential & Reference Input Bias Current		30	75	µA	0V	0V	+5.25V	+5.25V	+5.25V		±5.25V	
LM5520/LM5521: The following apply for $-55°C \leq T_A \leq 125°C$; LM7520/LM7521: The following apply for $0°C \leq T_A \leq 70°C$												
Differential Input Offset Current		0.5		µA	0V	0V	+5.25V	+5.25V	+5.25V		±5.25V	
Logic "1" Input Voltage												
(Strobes)	2			V	40 mV	20 mV	+2V	+4.75V		−400 µA(Q)	±5V	Logic Output >2.4V
(Gate Q)	2			V	40 mV	20 mV	0V	+2V		+16 mA(Q)	±5V	Logic Output <0.4V
(Gate $\bar{Q}$)	2			V	40 mV	20 mV	0V	0V	+2V	+16 mA($\bar{Q}$)	±5V	Logic Output <0.4V
Logic "0" Input Voltage												
(Strobes)			0.8	V	40 mV	20 mV	+0.8V	+4.75V		+16 mA(Q)	±5V	Logic Output <0.4V
(Gate Q)			0.8	V	40 mV	20 mV	0V	+0.8V		−400 µA(Q)	±5V	Logic Output >2.4V
(Gate $\bar{Q}$)			0.8	V	40 mV	20 mV	0V	0V	+0.8V	−400 µA($\bar{Q}$)	±5V	Logic Output >2.4V
Logic "0" Input Current		−1	−1.6	mA	40 mV	20 mV	+0.4V	+0.4V	+0.4V		±5.25V	Each Input
Logic "1" Input Current		5	40	µA	0V	20 mV	+2.4V	+5.25V	+2.4V		±5.25V	Each Input
(Strobe & Gate $\bar{Q}$)		.02	1	mA	0V	20 mV	+5.25V	+5.25V	+5.25V		±5.25V	Each Input
(Gate Q)		5	40	µA	40 mV	20 mV	+5.25V	+2.4V			±5.25V	
		.02	1	mA	40 mV	20 mV	+5.25V	+5.25V			±5.25V	
Logic "1" Output Voltage												
(Strobe)	2.4	3.9		V	40 mV	20 mV	+2.0V	+5.25V		−400 µA(Q)	±4.75V	
(Gate Q)	2.4	3.9		V	40 mV	20 mV	0V	+0.8V		−400 µA(Q)	±4.75V	
(Gate $\bar{Q}$)	2.4	3.9		V	40 mV	20 mV	+4.75V	0V	+0.8V	−400 µA($\bar{Q}$)	±4.75V	
Logic "0" Output Voltage												
(Strobe)		0.25	0.40	V	40 mV	20 mV	+0.8V	+4.75V		+16 mA(Q)	±4.75V	
(Gate Q)		0.25	0.40	V	0V	20 mV	0V	+2V		+16 mA(Q)	±4.75V	
(Gate $\bar{Q}$)		0.25	0.40	V	0V	20 mV	0V	0V	+2V	+16 mA($\bar{Q}$)	±4.75V	
Q Output Short Circuit Current	−3	−4	−5	mA	0V	20 mV	0V	0V		0 V(Q)	±5.25V	
$\bar{Q}$ Output Short Circuit Current	−2.1	−2.8	−3.5	mA	0V	20 mV	0V	0V	0V	0 V($\bar{Q}$)	±5.25V	
V+ Supply Current		21	35	mA	0V	20 mV	0V	0V	0V		±5.25V	
V− Supply Current		−13	−18	mA	0V	20 mV	0V	0V	0V		±5.25V	

Note 1: For $0°C \leq T_A \leq 70°C$ operation, electrical characteristics for LM5520 and LM5521 are guaranteed the same as LM7520 and LM7521, respectively.

Note 2: Limits in parentheses pertain to LM5521, other limits pertain to LM5520.

Note 3: Q or $\bar{Q}$ in parentheses indicate Q or $\bar{Q}$ logic output, respectively.

Note 4: Limits in parentheses pertain to LM7521, other limits pertain to LM7520.

Note 5: Positive current is defined as current into the referenced pin.

Note 6: Pin 1 to have $\geq$100 pF capacitor connected to ground.

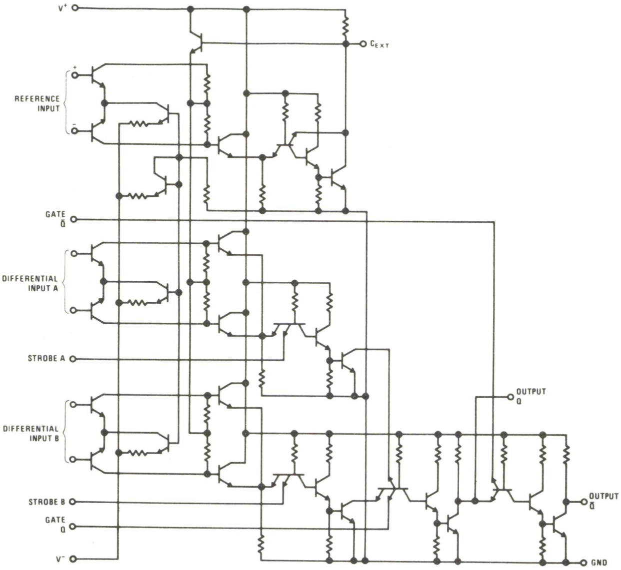
LM5520/LM7520 and LM5521/LM7521
electrical characteristics

LM5520/LM5521 and LM7520/LM7521: The following apply for T_A = 25°C, V^+ = 5V, V^- = −5V

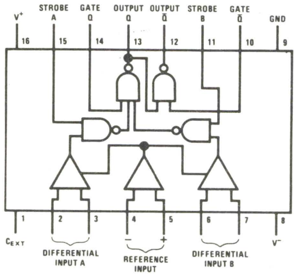
PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS				
					DIFF. INPUT	REF. INPUT	STROBE AND GATE INPUTS	Q LOGIC OUTPUT	AC TEST CIRCUIT
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE	
Propagation Delays									
Differential Input to Logical "1" Q Output		20	40	ns		20 mV			1
Differential Input to Logical "0" Q Output		28		ns		20 mV			1
Differential Input to Logical "1" $\bar{Q}$ Output		36		ns		20 mV			1
Differential Input to Logical "0" $\bar{Q}$ Output		28	55	ns		20 mV			1
Strobe Input to Logical "1" Q Output		10	30	ns		20 mV			1
Strobe Input to Logical "0" Q Output		20		ns		20 mV			1
Strobe Input to Logical "1" $\bar{Q}$ Output		33		ns		20 mV			1
Strobe Input to Logical "0" $\bar{Q}$ Output		16	55	ns		20 mV			1
Gate Q Input to Logical "1" Q Output		12	20	ns		20 mV			2
Gate Q Input to Logical "0" Q Output		6		ns		20 mV			2
Gate Q Input to Logical "1" $\bar{Q}$ Output		17		ns		20 mV			2
Gate Q Input to Logical "0" $\bar{Q}$ Output		19	30	ns		20 mV			2
Gate $\bar{Q}$ Input to Logical "1" $\bar{Q}$ Output		12		ns		20 mV			2
Gate $\bar{Q}$ Input to Logical "0" $\bar{Q}$ Output		6	20	ns		20 mV			2
Diff. Input Overload Recovery Time		10		ns					
Common-Mode Input Overload Recovery Time		5		ns					
Min. Cycle Time		200		ns					

LM5520/LM7520 and LM5521/LM7521

schematic diagram



connection diagram



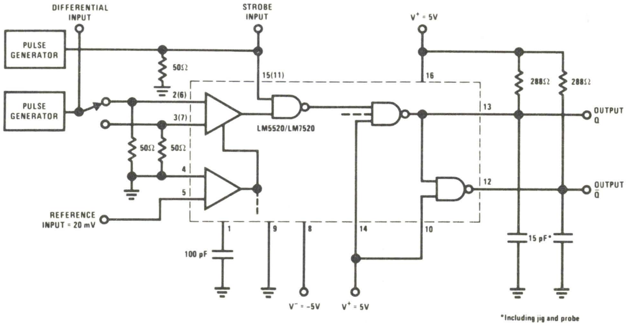
Order Number LM5520J or LM7520J
See Package 17

Order Number LM5520N or LM7520N
See Package 23

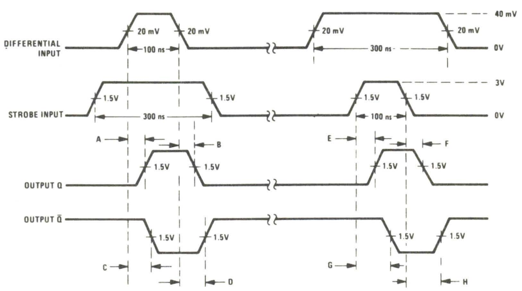
Order Number LM5521J or LM7521J
See Package 17

Order Number LM5521N or LM7521N
See Package 23

LM5520/LM7520 and LM5521/LM7521
AC test circuit (1)

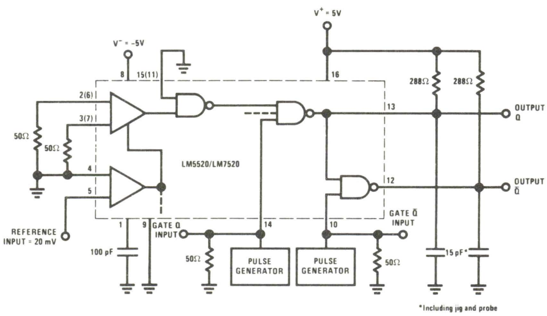


voltage waveforms (1)

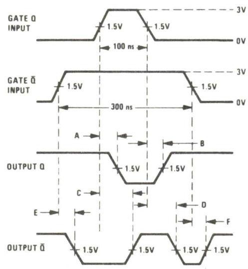


1. Pulse generator characteristics:
   $Z_{OUT} = 50\Omega$, $t_r = t_f = 15 \pm 5$ ns, PRR = 1 MHz
2. Propagation delays:
   A = Differential input to logical "1" output Q
   B = Differential input to logical "0" output Q
   C = Differential input to logical "0" output Q̄
   D = Differential input to logical "1" output Q̄
   E = Strobe input to logical "1" output Q
   F = Strobe input to logical "0" output Q
   G = Strobe input to logical "0" output Q̄
   H = Strobe input to logical "1" output Q̄

AC test circuit (2)



voltage waveforms (2)



1. Pulse generator characteristics:
   $Z_{OUT} = 50\Omega$, $t_r = t_f = 15 \pm 5$ ns, PRR = 1 MHz
2. Propagation delays:
   A = Gate Q input to logical "0" output Q
   B = Gate Q input to logical "1" output Q
   C = Gate Q input to logical "1" output Q̄
   D = Gate Q input to logical "0" output Q̄
   E = Gate Q̄ input to logical "0" output Q̄
   F = Gate Q̄ input to logical "1" output Q̄

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LM5522/LM7522 and LM5523/LM7523
electrical characteristics

LM5522/LM5523: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	GATE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V	−400 µA	±5V	Logic Output >2.4V
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V	+16 mA	±5V	Logic Output <0.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V	−400 µA	±5V	Logic Output >2.4V
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V	+16 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	100	µA	0V	0V	+5.25V	+5.25V		±5.25V	
LM7522/LM7523: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$											
Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V	−400 µA	±5V	Logic Output >2.4V
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V	+16 mA	±5V	Logic Output <0.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V	−400 µA	±5V	Logic Output >2.4V
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V	+16 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	75	µA	0V	0V	+5.25V	+5.25V		±5.25V	
LM5522/LM5523: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$; LM7522/LM7523: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$											
Diff. Input Offset Current		0.5		µA	0V	0V	+5.25V	+5.25V		±5.25V	
Logic "1" Input Voltage (Strobes)	2			V	40 mV	20 mV	+2V	+4.75V	+16 mA	±5V	Logic Output <0.4V
(Gate)	2			V	40 mV	20 mV	0V	+2V	−400 µA	±5V	Logic Output >2.4V
Logic "0" Input Voltage (Strobes)			0.8	V	40 mV	20 mV	+0.8V	+4.75V	−400 µA	±5V	Logic Output >2.4V
(Gate)			0.8	V	40 mV	20 mV	0V	+0.8V	+16 mA	±5V	Logic Output <0.4V
Logic "0" Input Current		−1	−1.6	mA	40 mV	20 mV	+0.4V	+0.4V		±5.25V	Each Input
Logic "1" Input Current (Strobes)			40	µA	0V	20 mV	+2.4V	+5.25V		±5.25V	
			1	mA	0V	20 mV	+5.25V	+5.25V		±5.25V	
(Gate)			40	µA	40 mV	20 mV	+5.25V	+2.4V		±5.25V	
			1	mA	40 mV	20 mV	+5.25V	+5.25V		±5.25V	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+0.8V	+2V	−400 µA	±4.75V	
Logic "0" Output Voltage (Strobes)		0.25	0.40	V	40 mV	20 mV	+2V	+4.75V	+16 mA	±4.75V	Tie Pins 10 and 12
(Gate)		0.25	0.40	V	40 mV	20 mV	0V	+0.8V	+16 mA	±4.75V	Tie Pins 10 and 12
Output Short Circuit Current	−2.1	−2.8	−3.5	mA	40 mV	20 mV	0V	+5.25V	0V	±5.25V	Tie Pins 10 and 12
Output Leakage Current		0.01	250	µA	0V	20 mV	0V	+2V	+5.25V	±4.75V	
V^+ Supply Current		23	36	mA	0V	20 mV	0V	0V		±5.25V	
V^- Supply Current		−13	−18	mA	0V	20 mV	0V	0V		±5.25V	
LM5522/LM5523 and LM7522/LM7523: The following apply for $T_A = 25^\circ C$, $V^+ = 5V$, $V^- = -5V$											
AC Common Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	+5V	SCOPE		
Propagation Delays: Differential Input to Logical "1" Output		26		ns		20 mV					AC Test Circuit
Differential Input to Logical "0" Output		21	45	ns		20 mV					AC Test Circuit
Strobe Input to Logical "1" Output		22		ns		20 mV					AC Test Circuit
Strobe Input to Logical "0" Output		12	40	ns		20 mV					AC Test Circuit
Gate Input to Logical "1" Output		4		ns		20 mV					AC Test Circuit
Gate Input to Logical "0" Output		15	25	ns		20 mV					AC Test Circuit
Differential Input Overload Recovery Time		10		ns							
Common Mode Input Overload Recovery Time		5		ns							
Min. Cycle Time		200		ns							

Note 1: For $0^\circ C \leq T_A \leq 70^\circ C$ operation, electrical characteristics for LM5522 and LM5523 are guaranteed the same as LM7522 and LM7523, respectively.

Note 2: Limits in parentheses pertain to LM5523, other limits pertain to LM5522.

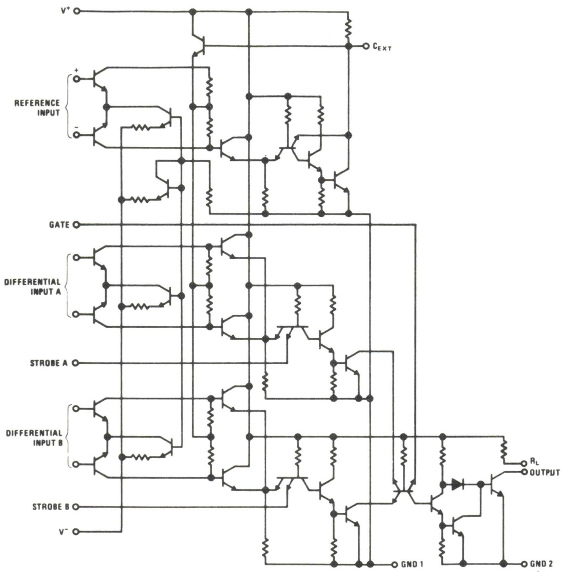
Note 3: Limits in parentheses pertain to LM7523, other limits pertain to LM7522.

Note 4: Positive current is defined as current into the referenced pin.

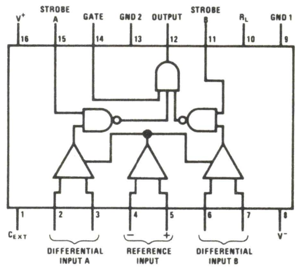
Note 5: Pin 1 to have $\geq$100 pF capacitor connected to ground.

LM5522/LM7522 and LM5523/LM7523

schematic diagram



connection diagram



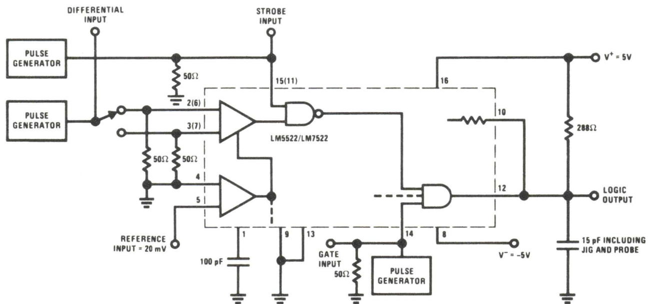
Order Number LM5522J or LM7522J
See Package 17

Order Number LM5522N or LM7522N
See Package 23

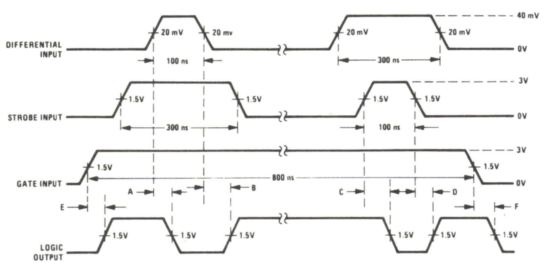
Order Number LM5523J or LM7523J
See Package 17

Order Number LM5523N or LM7523N
See Package 23

AC test circuit



voltage waveforms



1. One strobe is grounded when the other side is being tested
2. Pulse generator characteristics:
   Z_{OUT} = 50Ω, $t_r = t_f$ = 15±5 ns, PRR = 1 MHz
3. Propagation delays:
   A = Differential input to logical "0" output
   B = Differential input to logical "1" output
   C = Strobe input to logical "0" output
   D = Strobe input to logical "1" output
   E = Gate input to logical "1" output
   F = Gate input to logical "0" output

LM5524/LM7524 and LM5525/LM7525

electrical characteristics

LM5524/LM5525: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	–400 µA	±5V	Logic Output >2.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	–400 µA	±5V	Logic Output >2.4V
Differential & Reference Input Bias Current		30	100	µA	0V	0V	+5.25V		±5.25V	
LM7524/LM7525: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$										
Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	±5V ±5%	Logic Output <0.4V
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	–400 µA	±5V ±5%	Logic Output >2.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	±5V ±5%	Logic Output <0.4V
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	–400 µA	±5V ±5%	Logic Output >2.4V
Differential & Reference Input Bias Current		30	75	µA	0V	0V	+5.25V		±5.25V	
LM5524/LM5525: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$; LM7524/LM7525: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$										
Diff. Input Offset Current		0.5		µA	0V	0V	+5.25V		±5.25V	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	–400 µA	±5V	Logic Output >2.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+16 mA	±5V	Logic Output <0.4V
Logic "0" Input Current		–1	–1.6	mA	40 mV	20 mV	+0.4V		±5.25V	
Logic "1" Input Current		5	40	µA	0V	20 mV	+2.4V		±5.25V	
		0.02	1	mA	0V	20 mV	+5.25V		±5.25V	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+2.0V	–400 µA	±4.75V	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+0.8V	+16 mA	±4.75V	
Output Short Circuit Current	–2.1	–2.8	–3.5	mA	40 mV	20 mV	+5.25V	0V	±5.25V	
V^+ Supply Current		29	40	mA	0V	20 mV	0V		±5.25V	
V^- Supply Current		–13	–18	mA	0V	20 mV	0V		±5.25V	
LM5524/LM5525 and LM7524/LM7525: The following apply for $T_A = 25^\circ C$, $V^+ = 5V$, $V^- = -5V$										
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		20	40	ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		28		ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		10	30	ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		20		ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0^\circ C \leq T_A \leq 70^\circ C$ operation, electrical characteristics for LM5524 and LM5525 are guaranteed the same as LM7524 and LM7525 respectively.

Note 2: Limits in parentheses pertain to LM5525, other limits pertain to LM5524.

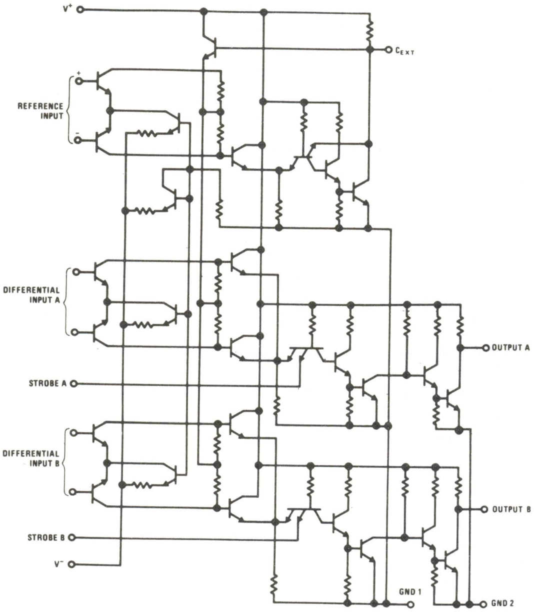
Note 3: Limits in parentheses pertain to LM7525, other limits pertain to LM7524.

Note 4: Positive current is defined as current into the referenced pin.

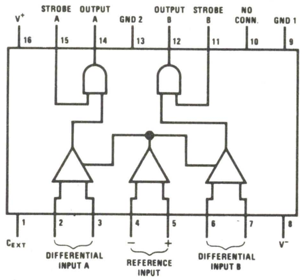
Note 5: Pin 1 to have $\geq$100 pF capacitor connected to ground.

LM5524/LM7524 and LM5525/LM7525

schematic diagram



connection diagram



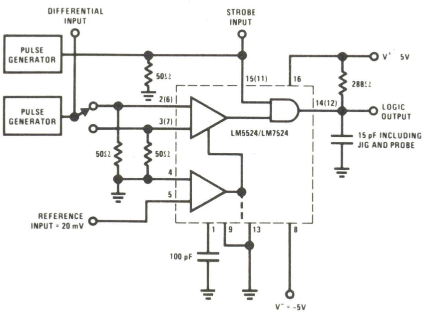
Order Number LM5524J or LM7524J
See Package 17

Order Number LM5524N or LM7524N
See Package 23

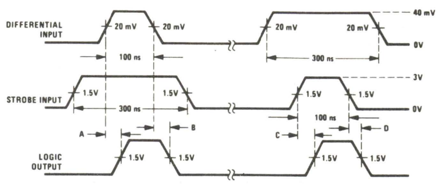
Order Number LM5525J or LM7525J
See Package 17

Order Number LM5525N or LM7525N
See Package 23

AC test circuit



voltage waveforms



1. Pulse generator characteristics:
$Z_{OUT} = 50\Omega$, $t_r = t_f = 15 \pm 5$ ns, PRR = 1 MHz
2. Propagation delays:
A = Differential input to logical "1" output
B = Differential input to logical "0" output
C = Strobe input to logical "1" output
D = Strobe input to logical "0" output

LM5528/LM7528 and LM5529/LM7529

electrical characteristics

LM5528/LM5529: The following apply for $-55°C \leq T_A \leq 125°C$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	−400 µA	±5V	Logic Output >2.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	−400 µA	±5V	Logic Output >2.4V
Differential & Reference Input Bias Current		30	100	µA	0V	0V	+5.25V		±5.25V	

LM7528/LM7529: The following apply for $0°C \leq T_A \leq 70°C$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	−400 µA	±5V	Logic Output >2.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	±5V	Logic Output <0.4V
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	−400 µA	±5V	Logic Output >2.4V
Differential & Reference Input Bias Current		30	75	µA	0V	0V	+5.25V		±5.25V	

LM5528/LM5529: The following apply for $-55°C \leq T_A \leq 125°C$
LM7528/LM7529: The following apply for $0°C \leq T_A \leq 70°C$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Diff. Input Offset Current		0.5		µA	0V	0V	+5.25V		±5.25V	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	−400 µA	±5V	Logic Output >2.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+16 mA	±5V	Logic Output <0 4V
Logic "0" Input Current		−1	−1.6	mA	40 mV	20 mV	+0.4V		±5.25V	
Logic "1" Input Current		5	40	µA	0V	20 mV	+2.4V		±5.25V	
		0.02	1	mA	0V	20 mV	+5.25V		±5.25V	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+2.0V	−400 µA	±4.75V	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+0.8V	+16 mA	±4.75V	
Output Short Circuit Current	−2.1	−2.8	−3.5	mA	40 mV	20 mV	+5.25V	0V	±5.25V	
V^+ Supply Current		29	40	mA	0V	20 mV	0V		±5.25V	
V^- Supply Current		−13	−18	mA	0V	20 mV	0V		±5.25V	

LM5528/LM5529 and LM7528/LM7529: The following apply for $T_A = 25°C$, $V^+ = 5V$, $V^- = -5V$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		20	40	ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		28		ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		10	30	ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		20		ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0°C \leq T_A \leq 70°C$ operation, electrical characteristics for LM5528 and LM5529 are guaranteed the same as LM7528 and LM7529 respectively.

Note 2: Limits in parentheses pertain to LM5529, other limits pertain to LM5528.

Note 3: Limits in parentheses pertain to LM7529, other limits pertain to LM7528.

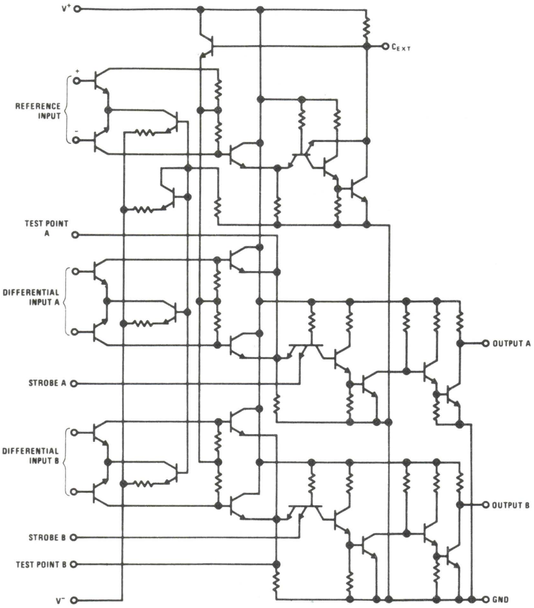
Note 4: Positive current is defined as current into the referenced pin.

Note 5: Pin 1 to have $\geq$100 pF capacitor connected to ground.

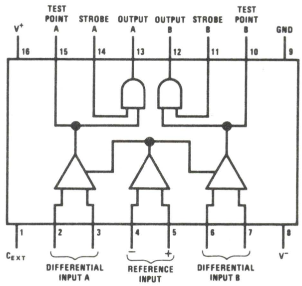
Note 6: Each test point to have $\leq$15 pF capacitive load to ground.

LM5528/LM7528 and LM5529/LM7529

schematic diagram



connection diagram



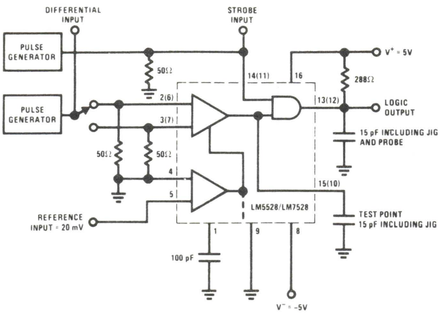
Order Number LM5528J or LM7528J
See Package 17

Order Number LM5528N or LM7528N
See Package 23

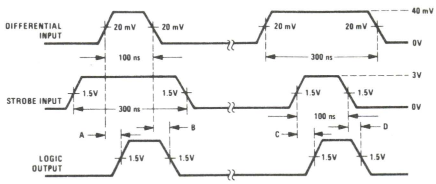
Order Number LM5529J or LM7529J
See Package 17

Order Number LM5529N or LM7529N
See Package 23

AC test circuit



voltage waveforms



1. Pulse generator characteristics:
$Z_{OUT} = 50\Omega$, $t_r = t_f = 15 \pm 5$ ns, PRR = 1 MHz
2. Propagation delays:
A = Differential input to logical "1" output
B = Differential input to logical "0" output
C = Strobe input to logical "1" output
D = Strobe input to logical "0" output

LM5534/LM7534 and LM5535/LM7535

electrical characteristics

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
LM5534/LM5535: The following apply for $-55°C \leq T_A \leq 125°C$ (Note 1)										
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	±5V	Logic Output <250 µA
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	±5V	Logic Output <0.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	±5V	Logic Output <250 µA
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	100	µA	0V	0V	+5.25V		±5.25V	
LM7534/LM7535: The following apply for $0°C \leq T_A \leq 70°C$										
Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	±5V	Logic Output <250 µA
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	±5V	Logic Output <0.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	±5V	Logic Output <250 µA
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	75	µA	0V	0V	+5.25V		±5.25V	
LM5534/LM5535: The following apply for $-55°C \leq T_A \leq 125°C$ LM7534/LM7535: The following apply for $0°C \leq T_A \leq 70°C$										
Diff. Input Offset Current		0.5		µA	0V	0V	+5.25V		±5.25V	
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+5.25V	±5V	Logic Output <250 µA
Logic "1" Input Voltage	2.0			V	40 mV	20 mV	+2.0V	+20 mA	±5V	Logic Output <0.4V
Logic "0" Input Current		−1	−1.6	mA	40 mV	20 mV	+0.4V		±5.25V	
Logic "1" Input Current		5	40	µA	0V	20 mV	+2.4V		±5.25V	
		0.02	1	mA	0V	20 mV	+5.25V		±5.25V	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+2V	+20 mA	±4.75V	
Output Leakage Current		0.01	250	µA	40 mV	20 mV	+0.8V	+5.25V	±4.75V	
V^+ Supply Current		28	38	mA	0V	20 mV	0V		±5.25V	
V^- Supply Current		−13	−18	mA	0V	20 mV	0V		±5.25V	
LM5534/LM5535 and LM7534/LM7535: The following apply for $T_A = 25°C$, $V^+ = 5V$, $V^- = -5V$										
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		24		ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		20	40	ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		16		ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		10	30	ns		20 mV				AC Test Circuit
Differential Input Over-load Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0°C \leq T_A \leq 70°C$ operation, electrical characteristics for LM5534 and LM5535 are guaranteed the same as LM7534 and LM7535 respectively.

Note 2: Limits in parentheses pertain to LM5535, other limits pertain to LM5534.

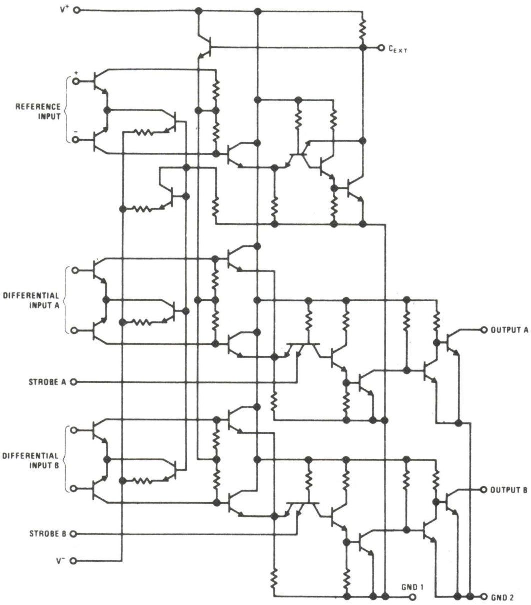
Note 3: Limits in parentheses pertain to LM7535, other limits pertain to LM7534.

Note 4: Positive current is defined as current into the referenced pin.

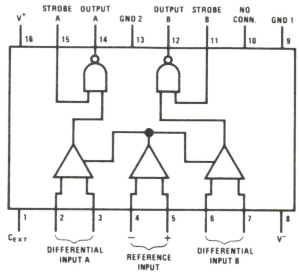
Note 5: Pin 1 to have $\geq$ 100 pF capacitor connected to ground.

LM5534/LM7534 and LM5535/LM7535

schematic diagram



connection diagram



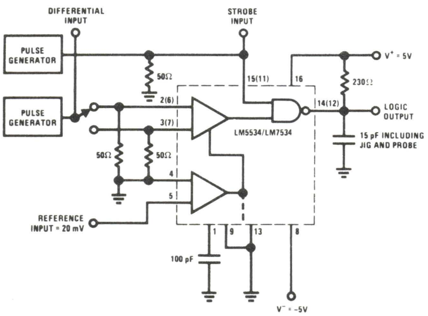
Order Number LM5534J or LM7534J
See Package 17

Order Number LM5534N or LM7534N
See Package 23

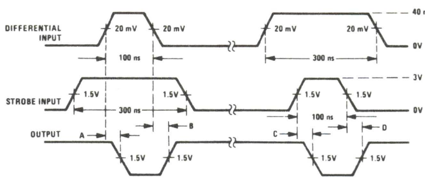
Order Number LM5535J or LM7535J
See Package 17

Order Number LM5535N or LM7535N
See Package 23

AC test circuit



voltage waveforms



1. Pulse generators have the following characteristics: $Z_{OUT} = 50\Omega$, $t_r = t_f = 15(\pm 5)$ ns, PRR = 1 MHz
2. Propagation delays:
   A = Differential input to logical "0" output
   B = Differential input to logical "1" output
   C = Strobe input to logical "0" output
   D = Strobe input to logical "1" output

LM5538/LM7538 and LM5539/LM7539
electrical characteristics

LM5538/LM5539: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER) DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	±5V	Logic Output <250 μA
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	±5V	Logic Output <0.4V
	35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	±5V	Logic Output <250 μA
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	100	μA	0V	0V	+5.25V		±5.25V	

LM7538/LM7539: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	±5V	Logic Output <250 μA
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	±5V	Logic Output <0.4V
	36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	±5V	Logic Output <250 μA
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	±5V	Logic Output <0.4V
Differential & Reference Input Bias Current		30	75	μA	0V	0V	+5.25V		±5.25V	

LM5538/LM5539: The following apply for $-55^\circ C \leq T_A \leq 125^\circ C$
LM7538/LM7539: The following apply for $0^\circ C \leq T_A \leq 70^\circ C$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V		±5.25V	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	+20 mA	±5V	Logic Output <0.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+5.25V	±5V	Logic Output <250 μA
Logic "0" Input Current		−1	−1.6	mA	40 mV	20 mV	+0.4V		±5.25V	
Logic "1" Input Current		5	40	μA	0V	20 mV	+2.4V		±5.25V	
		0.02	1	mA	0V	20 mV	+5.25V		±5.25V	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+2.0V	+20 mA	±4,75V	
Output Leakage Current		0.01	250	μA	40 mV	20 mV	+0.8V	+5.25V	±4.75V	
V^+ Supply Current		28	38	mA	0V	20 mV	0V		±5.25V	
V^- Supply Current		−13	−18	mA	0V	20 mV	0V		±5.25V	

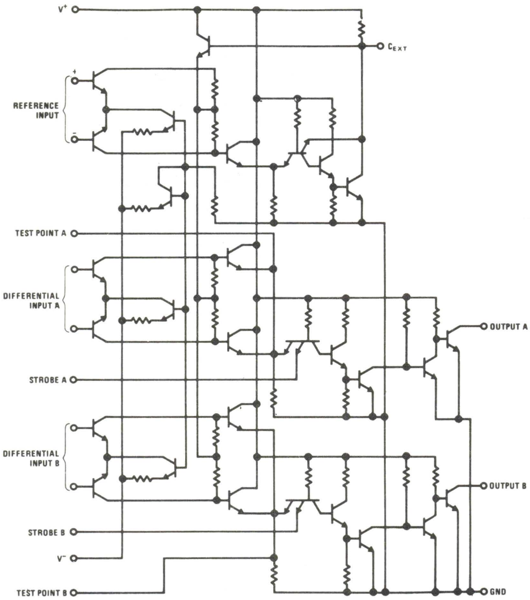
LM5538/LM5539 and LM7538/LM7539: The following apply for $T_A = 25^\circ C$, $V^+ = 5V$, $V^- = -5V$

PARAMETER	MIN	TYP	MAX	UNIT	DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	COMMENTS
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		24		ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		20	40	ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		16		ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		10	30	ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

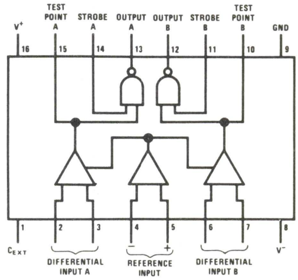
Note 1: For $0^\circ C \leq T_A \leq 70^\circ C$ operation, electrical characteristics for LM5538 and LM5539 are guaranteed the same as LM7538 and LM7539 respectively.
Note 2: Limits in parentheses pertain to LM5539, other limits pertain to LM5538.
Note 3: Limits in parentheses pertain to LM7539, other limits pertain to LM7538.
Note 4: Positive current is defined as current into the referenced pin.
Note 5: Pin 1 to have $\geq$100 pF capacitor connected to ground.
Note 6: Each test point to have $\leq$15 pF capacitive load to ground.

LM5538/LM7538 and LM5539/LM7539

schematic diagram



connection diagram



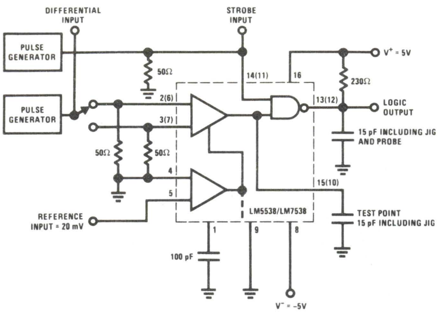
Order Number LM5538J or LM5538J
See Package 17

Order Number LM5538N or LM7538N
See Package 23

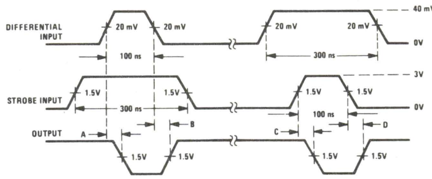
Order Number LM5539J or LM7539J
See Package 17

Order Number LM5539N or LM7539N
See Package 23

AC test circuit



voltage waveforms

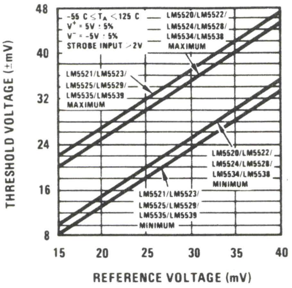


1. Pulse generators have the following characteristics: $Z_{OUT} = 50\Omega$, $t_r = t_f = 15(\pm 5)$ ns, PRR = 1 MHz
2. Propagation delays:
   A = Differential input to logical "0" output
   B = Differential input to logical "1" output
   C = Strobe input to logical "0" output
   D = Strobe input to logical "1" output

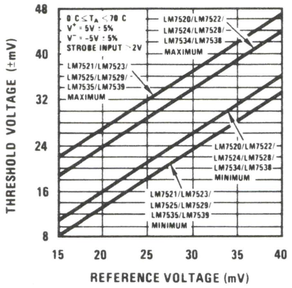
10

guaranteed performance characteristics

Differential Input Threshold Voltage

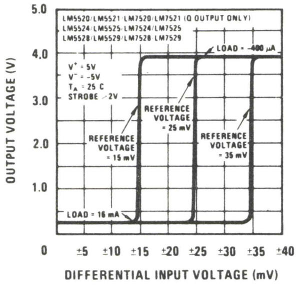


Differential Input Threshold Voltage

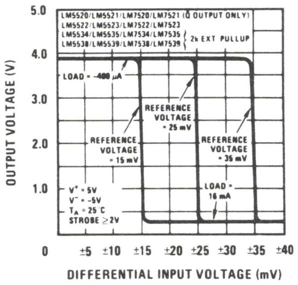


typical performance characteristics

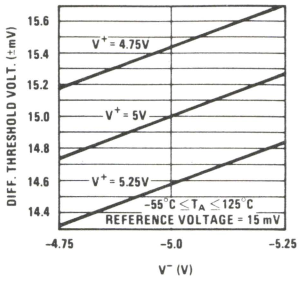
Transfer Characteristics



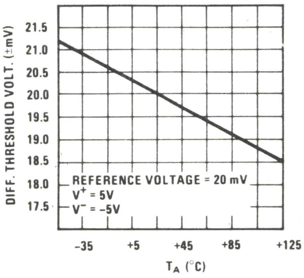
Transfer Characteristics



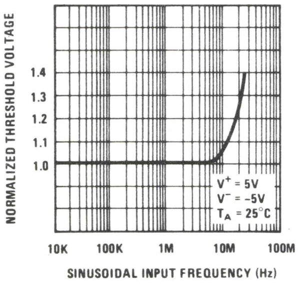
Power Supply Rejection



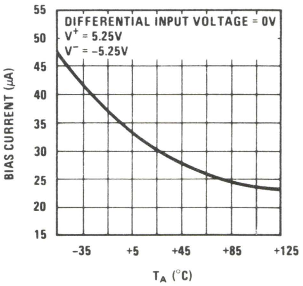
Temperature Coefficient



Differential Input Frequency Response

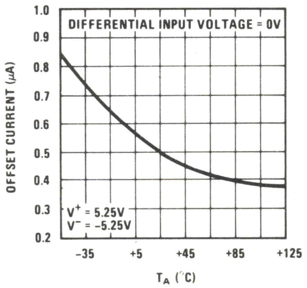


Differential Input Bias Current

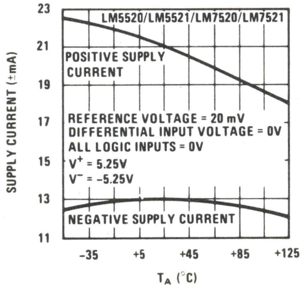


typical performance characteristics (cont.)

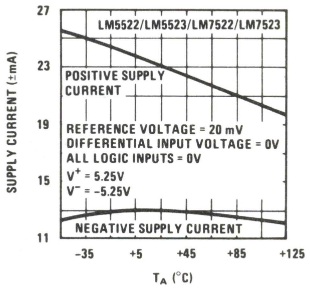
Differential Input Offset Current



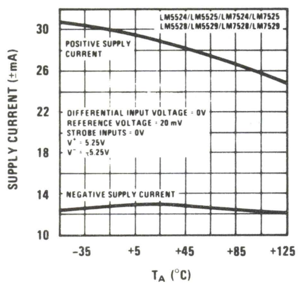
Power Supply Currents



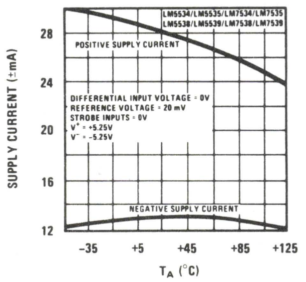
Power Supply Currents



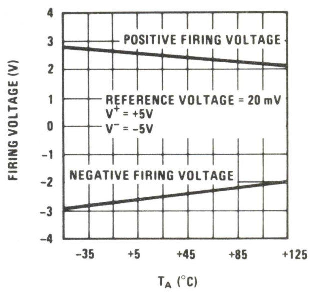
Power Supply Currents



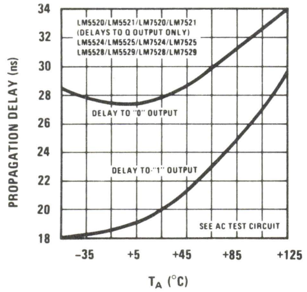
Power Supply Currents



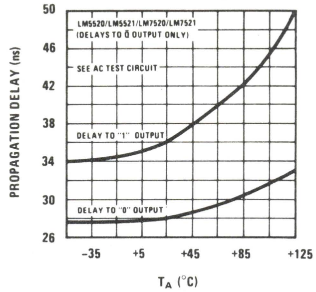
AC Common-Mode Firing Voltage



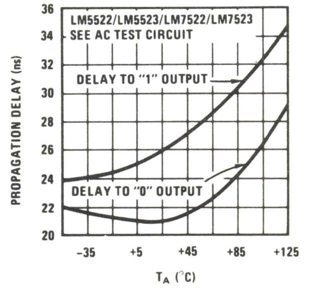
Differential Input to Output Propagation Delays



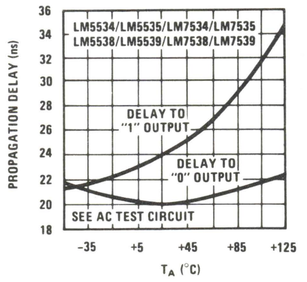
Differential Input to Output Propagation Delays



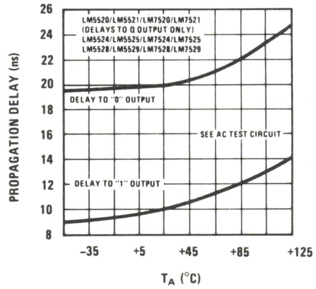
Differential Input to Output Propagation Delays



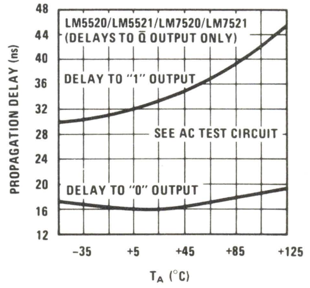
Differential Input to Output Propagation Delays



Strobe to Output Propagation Delays

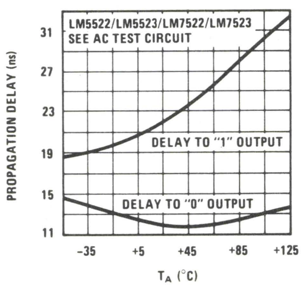


Strobe to Output Propagation Delays

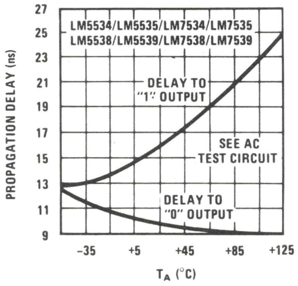


typical performance characteristics (cont.)

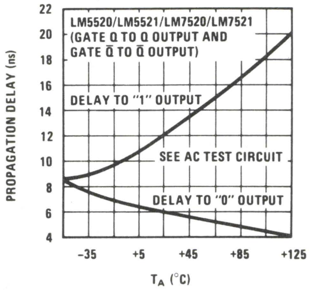
Strobe to Output Propagation Delays



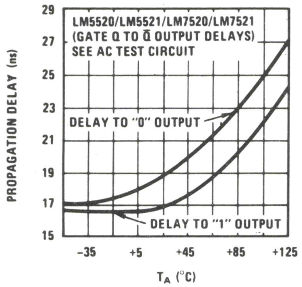
Strobe to Output Propagation Delays



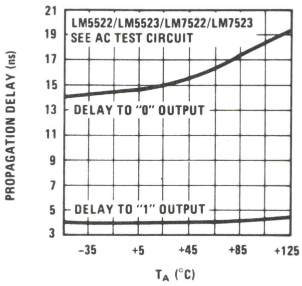
Gate to Output Propagation Delays



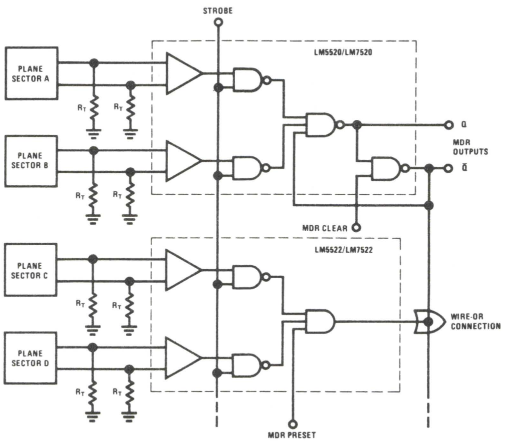
Gate to Output Propagation Delays



Gate to Output Propagation Delays

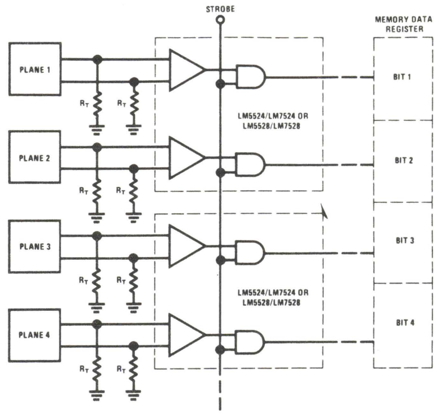


typical applications

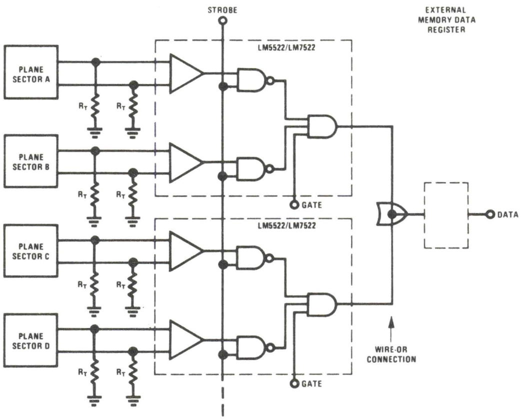


Large Memory System with Sectored Core Planes

typical applications (cont.)



Small Memory System



Large Memory System

New Products

LM125,LM126,LM127 dual complementary tracking voltage regulators

general description

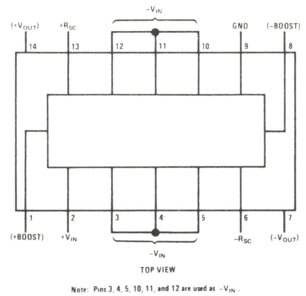
These are precision dual regulators with fixed outputs of ±15V (LM125), ±12V (LM126), and +5V, −12V (LM127), accurate to ±2%. Complete protection of the regulators is assured by internal short circuit current limit and thermal shutdown. Positive output voltage tracks negative output under all conditions. The circuit will be available in 9-lead power plastic dual-in-line and 10-lead TO-5 hermetic packages.

features

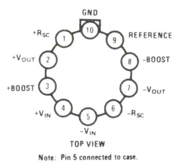
- Output currents — ±100 mA with provisions for current boost to 5 amps
- Low output drift — ±0.001%/°C
- Output impedance — 50 MΩ
- Internally compensated — few external components
- Other specs
  - Line regulation — 1 mV/V
  - Input/output differential — 2.5V min.
  - Maximum input — ±40V
  - Electronic shutdown — TTL compatible

connection diagrams

Dual-In-Line Package



Metal Can Package



LM143 high voltage operational amplifier

general description

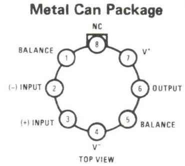
A general purpose internally compensated super β operational amplifier with operation to ±40V. The circuit is pin-for-pin compatible with the Motorola MC1536 but has improved offset, drift and input over-voltage characteristics. It will be available in an 8-lead TO-5 metal can package.

features

- Low input bias — 10 nA
- Low input offset current — 2 nA
- High slew rate — ±2.5V/µs
- Input over voltage protection — Full ±40V
- Pin compatible with Motorola MC1536 but has improved offset, drift and breakdown characteristics

connection diagram

Metal Can Package



11

LM378 4 watt/channel stereo amplifier

general description

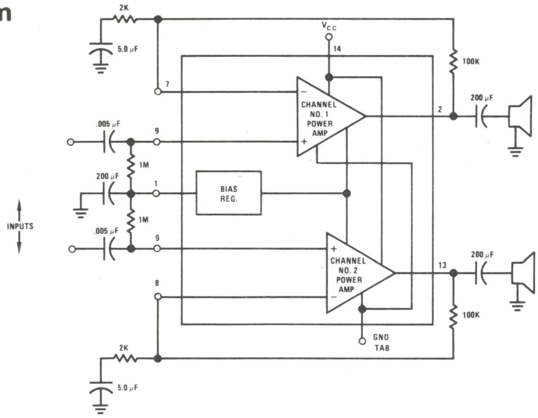
The LM378 is a monolithic dual power amplifier which offers high quality performance for stereo phonographs, tape players, and recorders, AM & FM stereo receivers, etc.

The LM378 will deliver 4 Watts/channel into a 16Ω load. The amplifier is designed to operate with a minimum of external components and contains an internal bias regulator to bias each amplifier and supply 80 dB supply rejection.

features

- High Gain — 100 dB/channel
- Low Distortion — 1% T.H.P.
- High Output Current — 1.2A
- Supply Voltage — 9-30V
- Internally Compensated
- Short Circuit Protection
- Thermal Limiting Protection

block diagram



LM383 5 watt power amplifier

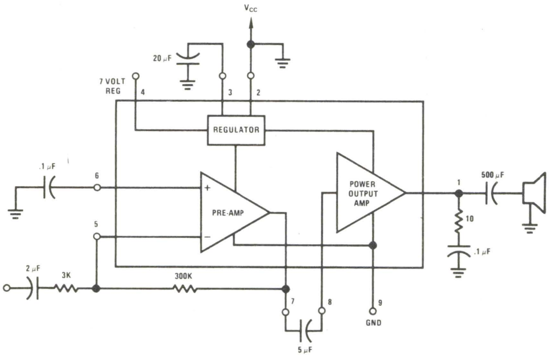
general description

The LM383 is a monolithic power amplifier capable of delivering 5 watts rms into a 4Ω load at 14V supply voltage. The amplifier includes a separate preamplifier and power amplifier giving an open loop gain of 15,000. Also provided on the chip is a power supply decoupler-regulator providing power supply rejection as well as an external 7V regulated reference voltage.

features

- Wide supply operating range — 8 – 18V
- High gain — Preamplifier 1500 V/V, Power amplifier 10 V/V
- Low distortion — 1% T.H.D.
- Wide power bandwidth — 40 kHz
- Short circuit protection
- Thermal limiting protection

block diagram



LM1805 TV signal processor

general description

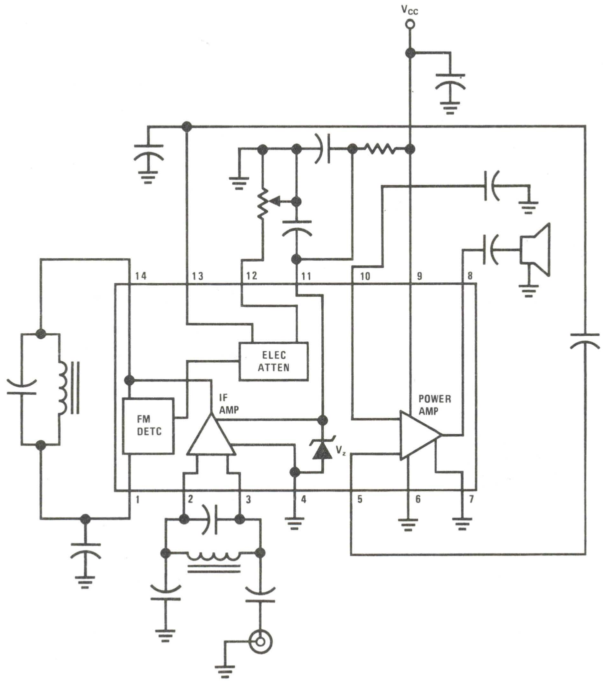
A complete two watt TV sound system, utilizing proven circuit techniques, has been incorporated in the LM1805. The FM IF portion utilizes a three stage limiting amplifier and a differential peak detector combined with a linear DC volume control. Designed for use with a minimum number of external components, the audio power amplifier section may be operated over a wide range of power supply and a speaker impedance combinations.

Thermal overload protection and current limiting insure reliable, fail safe operation in adverse enviornments.

features

- Regulator for FM IF section
- Low harmonic distortion
- Excellent AM rejection
- Fixed voitage gain in audio power amplifier
- 1.3 amp current capability
- Linear volume control

block diagram



DM7833,DM7834,DM7835,DM7839 quad TRI-STATE® transceiver

general description

This family of TRI-STATE™ party line transceivers offer extreme versatility in bus organized data transmission systems. The data bus may be unterminated, or terminated DC or AC at one or both ends. Drivers in the third (high impedance) state load the data bus with a negligible leakage current. The receiver input current is low allowing at least 100 driver/receiver pairs to utilize a single bus. The bus loading is unchanged when V_{CC} = 0V. The receiver incorporates hysteresis to provide greater noise immunity. All devices utilize a high current TRI-STATE output driver. The DM7833/DM8833 and DM7835/DM8835 employ TRI-STATE outputs on the receiver also, while on the DM7834/DM8834 and DM7839/DM8839 the receiver outputs are standard active pull up T^2L.

The DM7833/DM8833 are non-inverting quad transceivers with a common inverter driver disable control and a common inverter receiver disable control.

The DM7839/DM8839 are non-inverting quad transceivers with a common two-input driver disable control.

The DM7834/DM8834 are inverting quad transceivers with a common two input driver disable control.

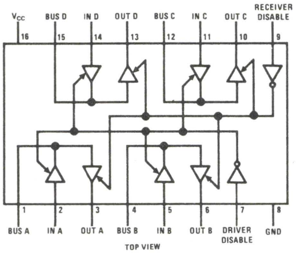
The DM7835/DM8835 are inverting quad transceivers with a common inverter driver disable control and a common inverter receiver disable control.

features

- Receiver hysteresis — 450 mV (typ)
- Receiver noise immunity — 1.4V (typ)
- Receiver input current for normal V_{CC} or V_{CC} = 0V — 50 μA (max)
- Receivers
  - Sink — 16 mA at 0.4V (max)
  - Source — 2.0 mA (mil), 5.2 mA (com) at 2.4V (min)
- Drivers
  - Sink — 50 mA at 0.5V (max) or 32 mA at 0.4V (max)
  - Source — 10.4 mA at 2.4V (min)
- Drivers have TRI-STATE outputs
- DM7833/DM8833 and DM7835/DM8835 receivers have TRI-STATE outputs
- Capable of driving 100Ω DC terminated buses
- 74 series TTL compatible

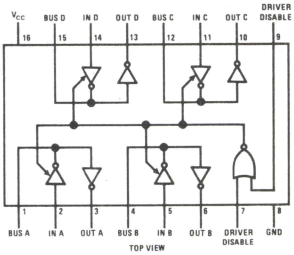
connection diagrams

Dual-In-Line Package



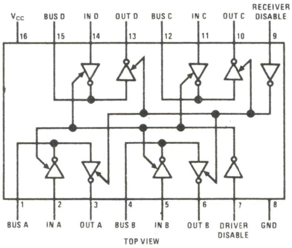
DM7833/DM8833

Dual-In-Line Package



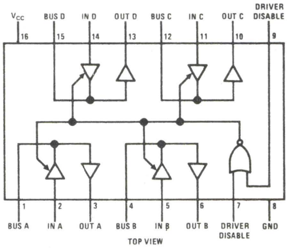
DM7834/DM8834

Dual-In-Line Package



DM7835/DM8835

Dual-In-Line Package



DM7839/DM8839

DM5446A/DM7446A, DM5447A/DM7447A, DM5448/DM7448 BCD to 7-segment decoder/drivers

DM7856/DM8856, DM8857, DM7858/DM8858 BCD-to-7-segment LED drivers

general description

This versatile series of 7-segment display drivers fullfills a wide variety of requirements for most active high or active low LED or lamp displays. Each device fully decodes a 4-bit BCD input into a number from 0 through 9 in the standard 7-segment display format, and BCD numbers above 9 into unique patterns that verify operation.

The DM5446A/DM7446A has active-low, open-collector outputs that will drive segments requiring up to 40 mA. The outputs will withstand 30V with a maximum reverse current of 250μA. In addition the circuit may be used to drive logic circuits with a normalized fanout of 25.

The DM5447A/DM7447A has the same output characteristics as the DM5446A/DM7446A except that the outputs withstand 15V at a maximum reverse current of 250μA.

The DM5448/DM7448 has active-high, passive-pull-up outputs with a fanout of 4 and typical source current of 2 mA at a voltage of 0.85V. It is normally used to drive logic circuits, operate high-voltage loads such as electroluminescent displays through buffer transistors or SCR switches, and in low current non-multiplex LED applications.

The DM7856/DM8856 has active-high, passive-pull-up outputs which provide a typical source current of 6 mA at an output voltage of 1.7V. The applications are the same as for the DM5448/DM7448 except that more design freedom is allowed with higher source levels.

The DM8857 has active-high outputs and is designed for multiplexing applications. It provides a typical source current of 50 mA at an output voltage of 2.3V.

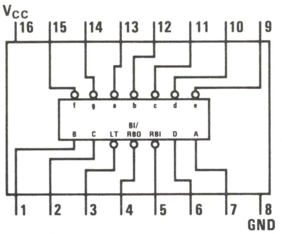
The DM7858/DM8858 has active high outputs with source current adjustable with an external resistor. This feature allows extreme flexibility in source current value selection for either multiplex or non-multiplex applications.

features

- Lamp-test input
- Leading/trailing zero suppression (RBI and RBO)
- Blanking input that may be used to modulate lamp intensity or inhibit output
- TTL and DTL compatible

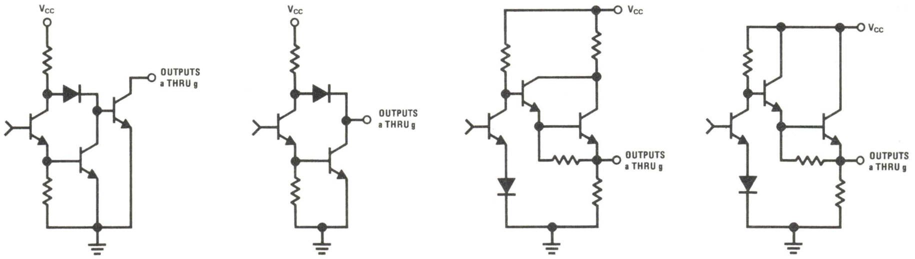
connection diagram

Dual-In-Line Package



TOP VIEW

output stage schematics



DM5446A/DM7446A
DM5447A/DM7447A

DM5448/DM7448
DM7856/DM8856

DM8857

DM7858/DM8858

DM8887 8-digit Panaplex II anode driver

general description

The DM8887 is designed to drive the individual anodes of a 7-segment high voltage gas-discharge panel in a time multiplexed fashion.

When driven with appropriate input signals, the driver will switch voltage and impedance levels at the anode. This will allow or prevent ionization of gas around selected cathodes in order to form a numeric display. Its main application will be to act as a buffer between MOS outputs (fully decoded) and the anodes of a gas-discharge panel, since it can source up to 16 mA at a low impedance and can tolerate more than −55V in the off state.

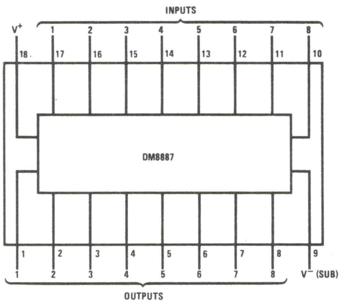
DM8889 high voltage segment driver

general description

DM8889 is capable of driving eight outputs with a constant output sink current programmable by an external resistor, R_P. The program current is half that of output on current. In the off state the outputs can tolerate more than 80V. The ration of "on" currents is within ±10%.

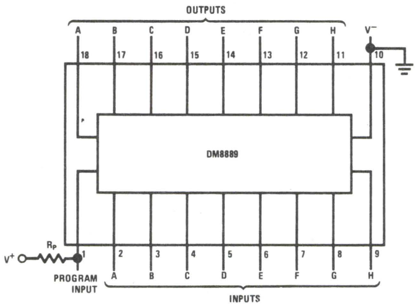
connection diagrams

Dual-In-Line Package



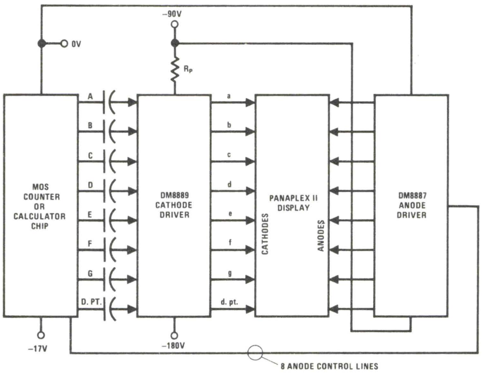
TOP VIEW

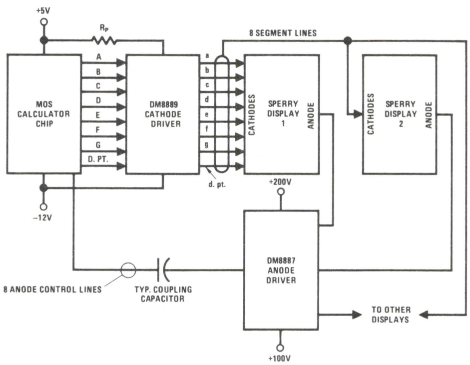
Dual-In-Line Package



TOP VI:

typical applications





MIL-STD-883/MIL-M-38510

MIL-STD-883

Mil-Standard-883 is a Test Methods and Procedures Document for Microelectronic Circuits. It was derived from MIL-S-19500, MIL-STD-750, and MIL-STD-202C for transistors and diodes at about the time that National Semiconductor Corporation was entering the military microelectronics market. As a result, our standard quality control operations are written around MIL-STD-883. The bonding control, visual inspections, and post seal screening requirements set forth by 883 (as well as added control procedures beyond the requirements of 883) have been part of National's quality control procedures almost from the start. Our Quality Assurance Procedures Manual is available upon request.

We offer a complete line of linear/883 (Class B) products as standard, off-the-shelf items. Special Linear/883 data sheets have been prepared to reflect this capability. They show process flow, electrical parameters, end of test criteria, and test circuits. We save you the problem of specifying test and inspection procedures, and offer significant cost savings by having an off-the-shelf, "to the letter" 883 program. In addition, we will test any of our integrated circuits to any class of MIL-STD-883.

The detailed information concerning MIL-STD-883 screening is contained in National's specification NSC10002.

MIL-M-38510

MIL-M-38510 specifies the general requirements for supplying microcircuits. These are; product assurance, which includes screening and quality conformance inspection; design and construction; marking; and workmanship. The screening and quality conformance inspection are conducted in accordance with MIL-STD-883.

SCREENING

All microcircuits delivered in accordance with MIL-M-38510 must have been subjected to, and passed all the screening tests detailed in Method 5004 of MIL-STD-883 for the type of microcircuit and product assurance level.

The device electrical and package requirements of MIL-M-38510 are detailed by a device specification referred to as a slash sheet. Each slash sheet defines the microcircuit electrical performance and mechanical requirements. Each device listed on a slash sheet is referred to as a slash number and the group of the microcircuits contained on a slash sheet is defined as a family of devices. The device may be Class B or C as defined by MIL-STD-883, Method 5004 and 5005. Three lead finishes are allowed by the slash sheet, pot solder dip, bright tin plate, and gold plate.

The MIL-M-38510 specs for standard linear devices require 100% DC testing at 25°C, −55°C and +125°C. AC testing is performed at +25°C. The electrical parameters specified are tighter than the normal data sheet guaranteed limits. Additionally, MIL-M-38510 requires device traceability, extensive documentation and closely matched maintenance.

QUALITY CONFORMANCE

Quality conformance inspection is conducted in accordance with the applicable requirements of Group A, (electrical test), Group B and C, (environmental test) of Method 5005, MIL-STD-883. These tests are conducted on a sample basis with Group A performed on each sublot, Group B on each lot, and Group C as specified (usually every three months).

To supply devices to MIL-M-38510, the IC manufacturer must quality the devices he plans to supply to the detail specifications. Qualification consists of notifying the qualifying activity of one's intent to qualify to MIL-M-38510. After passing comprehensive audits of facilities and documentation systems, the IC manufacturer will subject the device to and demonstrate that they satisfy all of

MIL-M-38510 (con't)

the Group A, B, and C requirements of Method 5005 of MIL-STD-883 for the specified classes and types of IC. The qualification tests shall be monitored by the qualifying agency. Finally the IC manufacturer shall prepare and submit qualification test data to the qualifying agency. Groups A, B, and C inspections then shall be performed at intervals no greater than three months.

The purpose of qualification testing is to assure that the device and lot quality conform to certain standard limits. In effect, lot qualification tests tend to ensure that once a particular device type is demonstrated to be acceptable, it's production, including materials, processing, and testing will continue to be acceptable. These limits are specified in MIL-STD-883 in terms of LTPD's (Lot Tolerance Percent Defective) for the various qualification test sub-groups. Qualification testing is performed on a sample of devices which are chosen at random from a lot of devices that has satisfactorily completed the screening of Method 5004 must be performed on each device, i.e. on a 100% basis as opposed to qualification testing (Method 5005) which occurs on a random sample basis.

In summary, the entire purpose of MIL-M-38510 and MIL-STD-883 is to provide the military, through its contractors with standard devices.

We at National Semiconductor have supplied and are supplying devices to the MIL-M-38510 specifications. To order a MIL-M-38510 microcircuit, specify the following:

For example; to specify an LM741 in a DIP processed to the requirements of MIL-M-38510, Class B, with gold plated leads, specify M-38510/10101BCC.

MM38510/	XXX	XX	X	X	X
Specifies the General Requirements of MIL-M-38510	Slash Sheet No.	Device Type	Device Class	Case Outline	Lead Finish

Definition of Terms

voltage regulators

Current-Limit Sense Voltage: The voltage across the current limit terminals required to cause the regulator to current-limit with a short circuited output. This voltage is used to determine the value of the external current-limit resistor when external booster transistors are used.

Dropout Voltage: The input-output voltage differential at which the circuit ceases to regulate against further reductions in input voltage.

Feedback Sense Voltage: The voltage, referred to ground, on the feedback terminal of the regulator while it is operating in regulation.

Input Voltage Range: The range of DC input voltages over which the regulator will operate within specifications.

Line Regulation: The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation: The change in output voltage for a change in load current at constant chip temperature.

Long Term Stability: Output voltage stability under accelerated life-test conditions at 125°C with maximum rated voltages and power dissipation for 1000 hours.

Maximum Power Dissipation: The maximum total device dissipation for which the regulator will operate within specifications.

Output-Input Voltage Differential: The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate within specifications.

Output Noise Voltage: The RMS AC voltage at the output with constant load and no input ripple, measured over a specified frequency range.

Output Voltage Range: The range of regulated output voltages over which the specifications apply.

Output Voltage Scale Factor: The output voltage obtained for a unit value of resistance between the adjustment terminal and ground.

Quiescent Current: That part of input current to the regulator that is not delivered to the load.

Ripple Rejection: The line regulation for AC input signals at or above a given frequency with a specified value of bypass capacitor on the reference bypass terminal.

Standby Current Drain: That part of the operating current of the regulator which does not contribute to the load current.

Temperature Stability: The percentage change in output voltage for a thermal variation from room temperature to either temperature extreme.

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operational amplifiers

Bandwidth: That frequency at which the voltage gain is reduced to $1/\sqrt{2}$ times the low frequency value.

Common Mode Rejection Ratio: The ratio of the input voltage range to the peak-to-peak change in input offset voltage over this range.

Harmonic Distortion: That percentage of harmonic distortion being defined as one-hundred times the ratio of the root-mean-square (rms) sum of the harmonics to the fundamental. % harmonic distortion =

$$\frac{(V_2^{\,2} + V_3^{\,3} + V_4^{\,2} + \ldots)^{1/2}\,(100\%)}{V_1}$$

where V_1 is the rms amplitude of the fundamental and V_2, V_3, V_4, . . . are the rms amplitudes of the individual harmonics.

Input Bias Current: The average of the two input currents.

Input Impedance: The ratio of input voltage to input current under the stated conditions for source resistance (R_S) and load resistance (R_L).

Input Offset Current: The difference in the currents into the two input terminals when the output is at zero.

Input Offset Voltage: That voltage which must be applied between the input terminals through two equal resistances to obtain zero output voltage.

Input Resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Input Voltage Range: The range of voltages on the input terminals for which the amplifier operates within specifications.

operational amplifiers (con't)

Large-Signal Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Output Impedance: The ratio of output voltage to output current under the stated conditions for source resistance (R_S) and load resistance (R_L).

Output Resistance: The small signal resistance seen at the output with the output voltage near zero.

Output Voltage Swing: The peak output voltage swing, referred to zero, that can be obtained without clipping.

Offset Voltage Temperature Drift: The average drift rate of offset voltage for a thermal variation from room temperature to the indicated temperature extreme.

Power Supply Rejection: The ratio of the change in input offset voltage to the change in power supply voltages producing it.

Settling Time: The time between the initiation of the input step function and the time when the output voltage has settled to within a specified error band of the final output voltage.

Slew Rate: The internally-limited rate of change in output voltage with a large-amplitude step function applied to the input.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.

Transient Response: The closed-loop step-function response of the amplifier under small-signal conditions.

Unity Gain Bandwidth: The frequency range from DC to the frequency where the amplifier open loop gain rolls off to one.

Voltage Gain: The ratio of output voltage to input voltage under the stated conditions for source resistance (R_S) and load resistance (R_L).

voltage comparators/buffers

Input Bias Current: The average of the two input currents.

Input Offset Current: The absolute value of the difference between the two input currents for which the output will be driven higher than or lower than specified voltages.

Input Offset Voltage: The absolute value of the voltage between the input terminals required to make the output voltage greater than or less than specified voltages.

Input Voltage Range: The range of voltage on the input terminals (common mode) over which the offset specifications apply.

Logic Threshold Voltage: The voltage at the output of the comparator at which the loading logic circuitry changes its digital state.

Negative Output Level: The negative DC output voltage with the comparator saturated by a differential input equal to or greater than a specified voltage.

Output Leakage Current: The current into the output terminal with the output voltage within a given range and the input drive equal to or greater than a given value.

Output Resistance: The resistance seen looking into the output terminal with the DC output level at the logic threshold voltage.

Output Sink Current: The maximum negative current that can be delivered by the comparator.

Positive Output Level: The high output voltage level with a given load and the input drive equal to or greater than a specified value.

Power Consumption: The power required to operate the comparator with no output load. The power will vary with signal level, but is specified as a maximum for the entire range of input signal conditions.

Response Time: The interval between the application of an input step function and the time when the output crosses the logic threshold voltage. The input step drives the comparator from some initial, saturated input voltage to an input level just barely in excess of that required to bring the output from saturation to the logic threshold voltage. This excess is referred to as the voltage overdrive.

Saturation Voltage: The low-output voltage level with the input drive equal to or greater than a specified value.

Strobe Current: The current out of the strobe terminal when it is at the zero logic level.

Strobed Output Level: The DC output voltage, independent of input conditions, with the voltage on the strobe terminal equal to or less than the specified low state.

Strobe ON Voltage: The maximum voltage on either strobe terminal required to force the output to the specified high state independent of the input voltage.

voltage comparators/buffers (con't)

Strobe OFF Voltage: The minimum voltage on the strobe terminal that will guarantee that it does not interfere with the operation of the comparator.

Strobe Release Time: The time required for the output to rise to the logic threshold voltage after the strobe terminal has been driven from zero to the one logic level.

Supply Current: The current required from the positive or negative supply to operate the comparator with no output load. The power will vary with input voltage, but is specified as a maximum for the entire range of input voltage conditions.

Voltage Gain: The ratio of the change in output voltage to the change in voltage between the input terminals producing it.

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functional blocks

(LM122/LM222/LM322, LM2905/LM3905 only)

Maximum Power Dissipation: The maximum total device dissipation for which the timer will operate within specifications.

Timing Ratio: The ratio of the firing voltage at the R/C pin to the reference voltage.

Comparator Input Current: The average current flowing from the R/C pin during the timing cycle.

Trigger Voltage: The voltage required at the trigger terminal to initiate a timing cycle, referenced to the ground pin.

Output Leakage Current: The maximum current flowing into the collector of the output transistor when the transistor is in the "off" state.

Reset Resistor: The equivalent resistor which may be used to calculate the discharge time of the timing capacitor. $t_{DISCHARGE} = (5)\ (C_t)\ (R_{RESET})$.

Collector Saturation Voltage: The collector to emitter voltage on the output transistor when it is in the "on" state with specified sink current flowing into the collector terminal.

Emitter Saturation Voltage: The voltage across the output transistor when the collector is tied to V^+, the transistor is in the "on" state, and the specified output current is flowing from the emitter terminal.

Capacitor Saturation Voltage: The offset voltage remaining on the timing capacitor after capacitor discharge current has dropped to zero.

Trigger Current: The current flowing into or out of the trigger terminal at the specified trigger voltage.

R_t: Timing resistor connected between V_{REF} and the R/C terminal.

C_t: Timing capacitor connected between the R/C terminal and the ground terminal.

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consumer circuits

AGC DC Output Shift: The shift of the quiescent IC output voltage of the AGC section for a given change in AGC central voltage.

AGC Figure of Merit (AGC Range): The widest possible range of input signal level required to make the output drop by a specified amount from the specified maximum output level.

AGC Input Current: The current required to bias the central voltage input of the AGC section.

AM Rejection Ratio: The ratio of the recovered audio output produced by a desired FM signal of specified level and duration to the recovered audio output produced by an unwanted AM signal of specified amplitude and modulating index.

Channel Separation: The level of output signal of an undriven amplifier with respect to the output level of an adjacent driven amplifier.

Detection Bandwidth: That frequency range about the free running frequency of the tone decoder/phase locked loop where a signal above a specified level will cause a detected signal condition at the output.

Detection Bandwidth Skew: The measure of how well the detection bandwidth is centered about the free running frequency. It is equal to the maximum detection bandwidth frequency plus the minimum detection bandwidth frequency minus twice the free running frequency.

Hold In Range: That range of frequencies about the free running frequency for which the phase locked loop will stay in lock if initially starting out in lock.

Input Bias Current: The average of the two input currents.

consumer circuits (con't)

Input Resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Input Sensitivity: The minimum level of input signal at a specified frequency required to produce a specified signal-to-noise ratio at the recovered audio output.

Input Voltage Range: The range of voltages on the input terminals for which the amplifier operates within specifications.

Large-Signal Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Limiting Threshold: In FM the input signal level which causes the recovered audio output level to drop 3 dB from the output level with a specified large signal input.

Lock In Range: That range of frequencies about the free running frequency for which the phase locked loop will come into lock if initially starting out of lock.

Maximum Sweep Rate: The maximum rate that the VCO may be made to vary its oscillating frequency over its Sweep Range.

Output Resistance: The ratio of the change in output voltage to the change in output current with the output around zero.

Output Voltage Swing: The peak output voltage swing, referred to zero, that can be obtained without clipping.

Phase Detector Sensitivity: The change in the output voltage of the phase detector for a given change in phase between the two input signals to the phase detector.

Power Bandwidth: That frequency at which the voltage gain reduces to $1/\sqrt{2}$ with respect to the flat band voltage gain specified for a given load and output power.

Power Supply Rejection: The ratio of the change in input offset voltage to the change in power supply voltages producing it.

Slew Rate: The internally limited rate of change in output voltage with a large amplitude step function applied to the input.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.

Sweep Range: That ratio of maximum oscillating frequency to minimum operating frequency produced by varying the central voltage of the VCO from its maximum value to its minimum value with fixed values of timing resistance and capacitance.

VCO Sensitivity: The change in operating frequency for a given change in VCO central voltage.

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analog switches

Driver Leakage Current: The sum of the currents into the source and drain switch terminals, with both held at the same specified voltage.

Logic "1" Input Voltage: The voltage level which is guaranteed to be interpreted by the device as a logical "true" signal.

Logic "0" Input Voltage: The voltage level which is guaranteed to be interpreted by the device as a logical "false" signal.

Logic Input Slew Rate: The voltage difference between the logic "1" and logic "0" states divided by the transistion time.

Switch Leakage Current: The current seen when a specified voltage is applied between drain and source of a channel that is logically turned off.

Switch On Resistance: The equivalent resistance from source to drain, tested by forcing a specified current and measuring the resultant voltage drop.

Switch Turn-Off Time: The interval between the time that the logic input passes through the threshold voltage and the time that the output goes to a specified voltage level in the test circuit.

Switch Turn-On Time: The interval between the time that the logic input passes through the threshold voltage and the time that the output goes to 90% of its final value in the specified test circuit.

interface circuits

Common Mode Voltage: Arithmetic mean of voltages at the differential inputs referenced to ground pin at the receiver.

Common Mode Sensitivity: Rate of change of input differential voltage required to produce a given output level, against common mode voltage.

Supply Sensitivity: Rate of change of input differential voltage required to prodcue a given output level, against power supply voltage (V Pin 14 — V Pin 7).

Disabled Output Clamp Current: The current which flows from the output of a disabled TRI-STATE gate when it is dragged below ground (for instance by a transmission-line-associated transient). It is derived from the V_{CC} power rail.

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sense amplifiers

AC Common-Mode Input Firing Voltage: The peak level of a common-mode pulse which will exceed the input dynamic range and cause the logic output to switch. Pulse characteristics: $t_r = t_f \leq 15$ ns, PW = 50 ns.

Common-Mode Input Overload Recovery Time: The time necessary for the device to recover from a ±2V common-mode pulse ($t_r = t_f = 20$ ns) prior to the strobe enable signal.

Differential Input Offset Current: The absolute difference in the two input bias currents of one differential input.

Differential Input Overload Recovery Time: The time necessary for the device to recover from a 2V differential pulse ($t_f = t_r = 20$ ns) prior to the strobe enable signal.

Differential Input Threshold Voltage: The DC input voltage which forces the logic output to the logic threshold voltage (~1.5V) level.

Input Bias Current: The DC current which flows into each input pin with differential input of 0V.

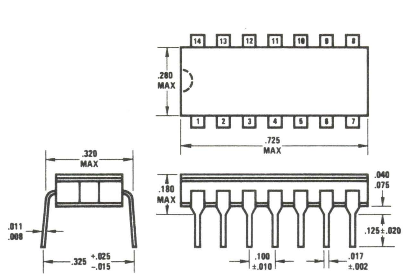
Supply Current: The total DC current per package drawn from the voltage supply.

Offset Voltage: Difference between the absolute values of threshold voltage in positive- and negative-going directions.

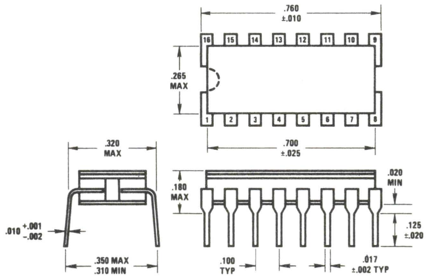
Propagation Delay Time: Interval from switching input through 1.5V to output traversing its 50% voltage point. Measured with 50Ω load to +10V 15 pF total capacitance.

Physical Dimensions

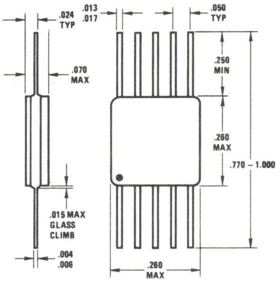
(All dimensions are in inches.)



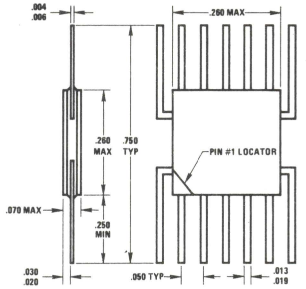
Package 1
14 Lead Cavity DIP (D)



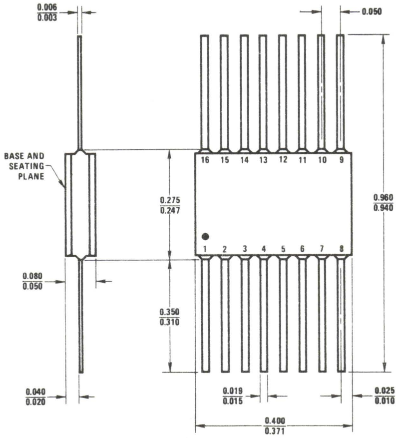
Package 2
16 Lead Cavity DIP (D)



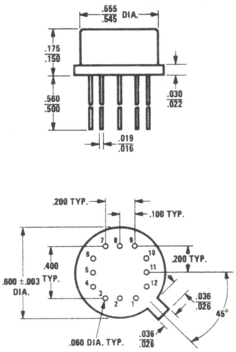
Package 3
10 Lead Flat Package (F)



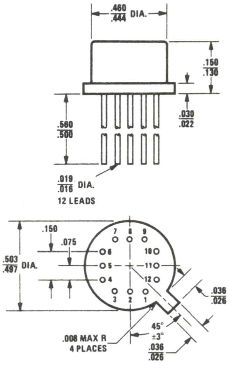
Package 4
14 Lead Flat Package (F)



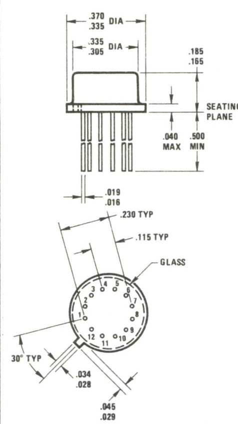
Package 5
16 Lead Flat Package (F)



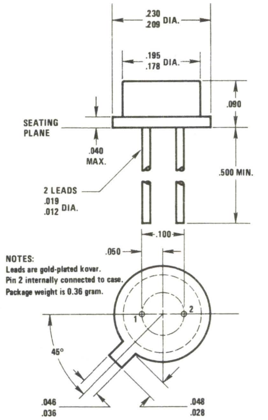
Package 6
12 Lead TO-8 Metal Can (G)



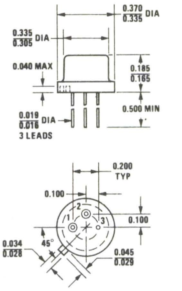
Package 6A
12 Lead TO-8 Metal Can (G)
(AH2114/AH2114C only)



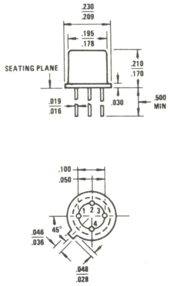
Package 7
12 Lead TO-8 Metal Can (H)



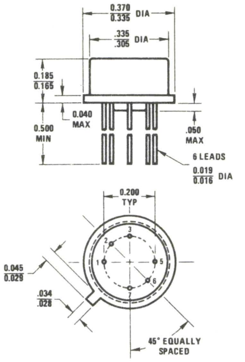
Package 8
2 Lead TO-46 Metal Can (H)



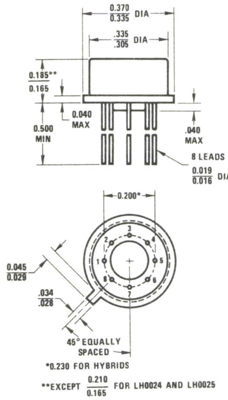
Package 9
3 Lead TO-5 Metal Can (H)



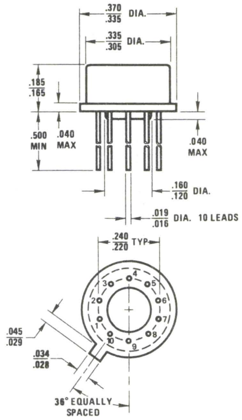
Package 9A
4 Lead TO-72 Metal Can (H)



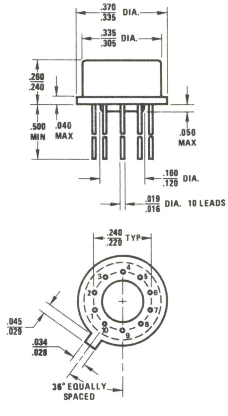
Package 10
6 Lead TO-5 Metal Can (H)



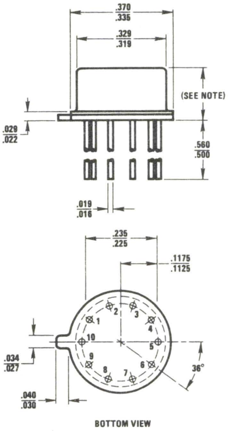
Package 11
8 Lead TO-5 Metal Can (H)



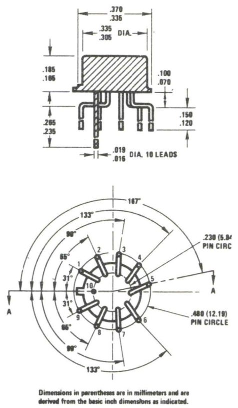
Package 12
10 Lead TO-5 Metal Can (H)
(Low Profile)



Package 13
10 Lead TO-5 Metal Can (H)
(High Profile)

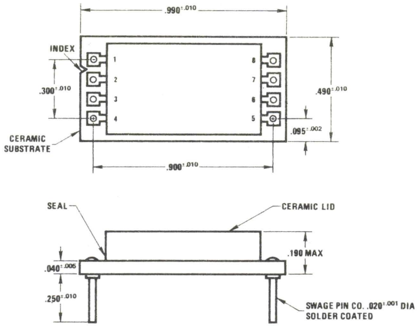


Package 14
10 Lead TO-5 Metal Can (H)

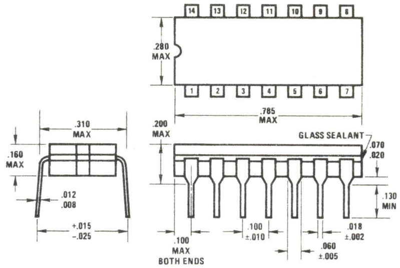


Package 14A
10 Lead Metal Can (H-03)

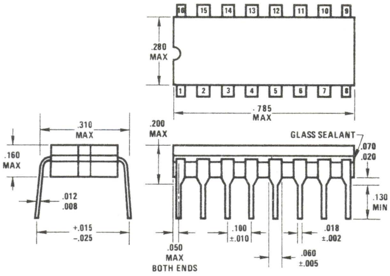
Note: Dimension is $\frac{.155}{.185}$ for all products except as follows: $\frac{.260}{.290}$ for LH0001H/LH0001CH,LH0003/LH000CH,and LH0004/LH0004CH: $\frac{.240}{.260}$ for LH0005AH/LH0005H/LH0005CH; $\frac{.180}{.210}$ for MH0007H/MH0007CH.



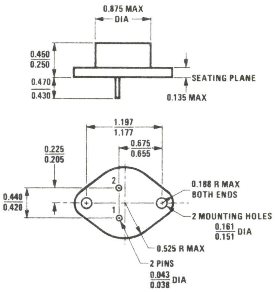
Package 15
8 Lead Cavity Package (J)



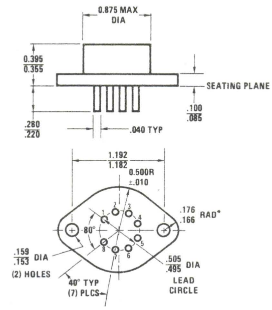
Package 16
14 Lead Cavity DIP (J)



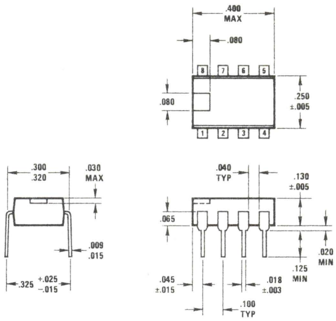
Package 17
16 Lead Cavity DIP (J)



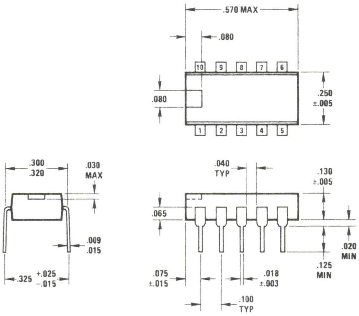
Package 18
2 Lead TO-3 Metal Can (K)



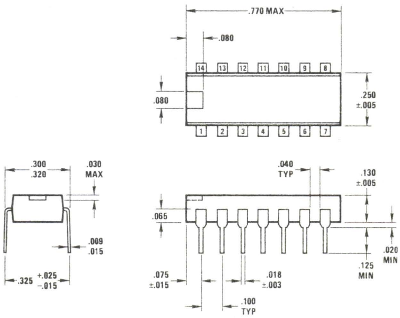
Package 19
8 Lead TO-3 Metal Can (K)



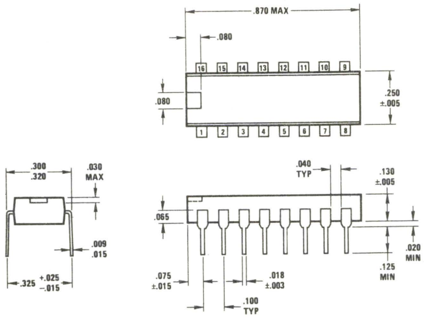
Package 20
8 Lead Molded Mini DIP (N)



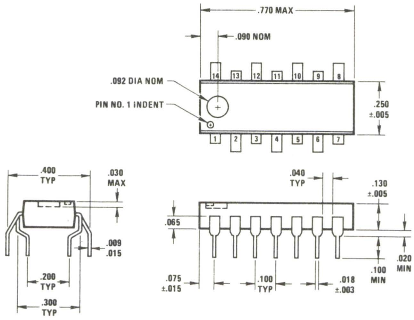
Package 21
10 Lead Molded DIP (N)



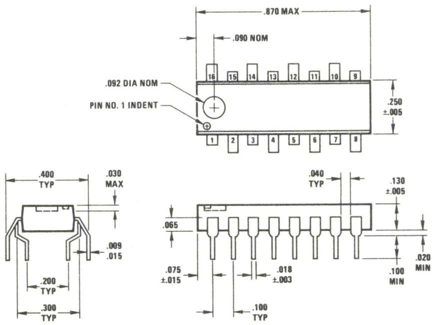
Package 22
14 Lead Molded DIP (N)



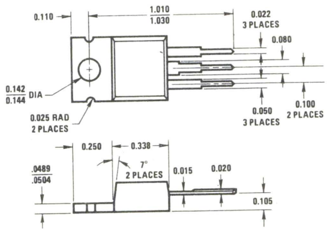
Package 23
16 Lead Molded DIP (N)



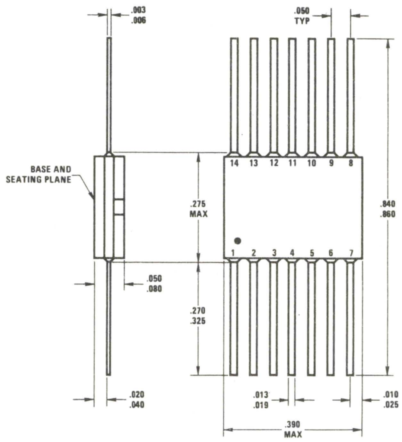
Package 24
14 Lead Molded DIP (N-01)
(Staggered Leads)



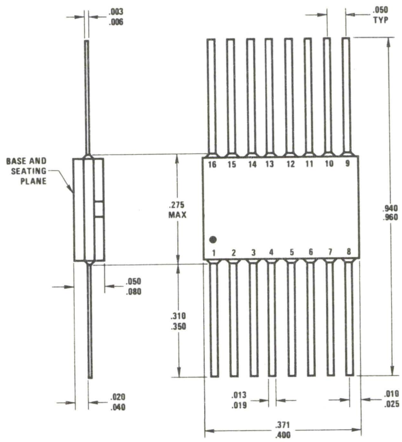
Package 25
16 Lead Molded DIP (N-01)
(Staggered Leads)



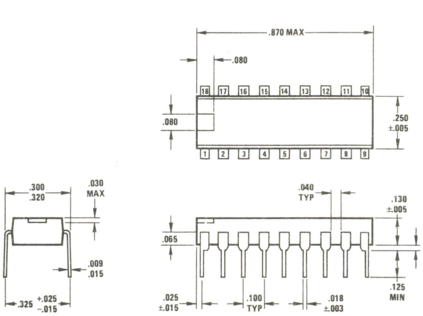
Package 26
3 Lead TO-220 Power Package (T)



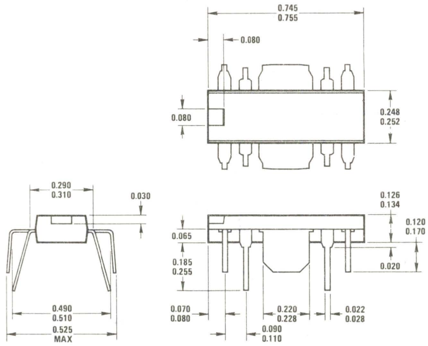
Package 27
14 Lead Flat Package (W)



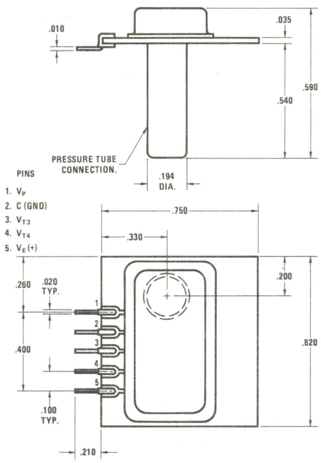
Package 28
16 Lead Flat Package (W)



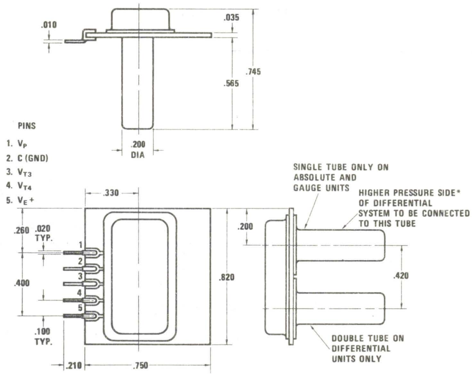
Package 29
18 Lead Molded DIP (N)



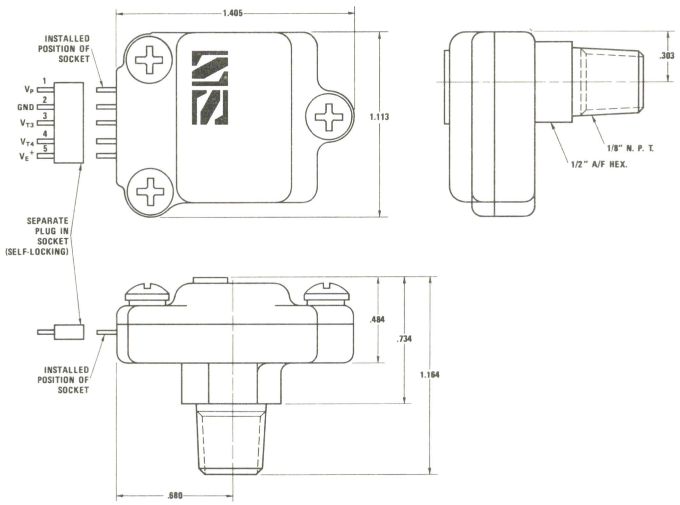
Package 30
14 Lead Batwing DIP (N)



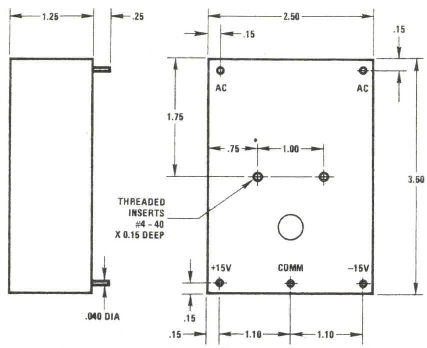
Package 31
Pressure Transducer



Package 32
Pressure Transducer

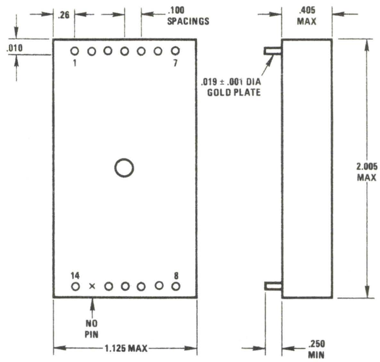


Package 33
Pressure Transducer



(SIDE VIEW) (BOTTOM VIEW)

Package 34
Molded Module



(BOTTOM VIEW) (SIDE VIEW)

Package 35
Molded Module

INCHES TO MILLIMETERS CONVERSION TABLE					
INCHES	MM	INCHES	MM	INCHES	MM
.001	.0254	.010	.254	.100	2.54
.002	.0508	.020	.508	.200	5.08
.003	.0762	.030	.762	.300	7.62
.004	.1016	.040	1.016	.400	10.16
.005	.1270	.050	1.270	.500	12.70
.006	.1524	.060	1.524	.600	15.24
.007	.1778	.070	1.778	.700	17.78
.008	.2032	.080	2.032	.800	20.32
.009	.2286	.090	2.286	.900	22.86

Notes

Notes

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